Lot and the Refrigerant Plant. It should be noted, that no PCBs were detected in excess of the SSL from any samples deeper than the 4-6 ft bgs interval. Samples from UND-4 and UND-5 with exceedances of the SSL were collected from areas containing described waste materials (see Appendix C).

2.2.1.4 TPH

Approximately 1125 soil samples were collected at approximately 414 locations during Step 1 through Step 5 activities for TPH analysis. TPH was detected in a majority of the samples. Per the SSL evaluation process described in the Soil RI Report (Parsons 2004d), the TPH SSLs for the three carbon ranges are 500 mg/kg, 1,000 mg/kg, and 10,000 mg/kg, respectively. The greatest percentage of TPH detections in samples were in the C23–C32 range (between 22% and 31%), followed by the C13–C22 (between 9% and 18%) and C6–C12 (7%) ranges, respectively. Therefore, the SSL for gasoline range organic hydrocarbons (GRO) is 500 mg/kg and the SSL for total TPH is 1,000 mg/kg.

The following table summarizes the TPH (both GRO and total TPH) sample results detected at concentrations in excess of the SSL.

Subarea	Depth Interval (ft bgs)	Sample Location	Sample ID	GRO / Total TPH (concentration in mg/kg)
DIESEL BUILDING	0-0.5 Ft	Demo-FWT-01	Demo-FWT-01-01	(<0.83 / 23480)
	0-0.5 Ft	Demo-FWT-02	Demo-FWT-02-01	(<0.81 / 39380)
	0-0.5 Ft	Demo-FWT-03	Demo-FWT-03-01	(<0.85 / 23830)
ORTHOXYLENE	0-0.5 Ft	Demo-WWSWTS-1	Demo-WWSWTS-1-1	(<0.11 / 5620)
	0-0.5 Ft	Demo-WWSWTS-2	Demo-WWSWTS-2-1	(0.36 / 76030)
	0-0.5 Ft	Demo-WWSWTS-3	Demo-WWSWTS-3-1	(1100 / 4800)
OTHER	4-6 Ft	SB-K05	SB-K05-2	(<0.1 / 2961)
PHTHALIC ANHYDRIDE	0-0.5 Ft	SB-H04-A2	SB-H04-A2-1	(<0.13 / 2700)
	0-0.5 Ft	Demo-PAA-1	Demo-PAA-1-1	(2900 / 2800)
	0-0.5 Ft	Demo-PASA-1	Demo-PASA-1-1	(<0.11 / 1310)
	0-0.5 Ft	SB-PIRM-74	SB-PIRM-74-1	(<0.18 / 15900)
REFRIGERANT PLANT	0-0.5 Ft	SB-C09-C	SB-C09-C-1	(0.8 / 4600.8)
		SB-F07-A	SB-F07-A-1	(0.22 / 1600.22)
		SB-PIRM-25	SB-PIRM-25-1	(69 / 3269)
	4-6 Ft	SB-F07-D	SB-F07-D-2	(92 / 1692)
	8-10 Ft	SB-F07-D	SB-F07-D-3	(300 / 6900)
	0-0.5 Ft	Demo-141DTC-1	Demo-141DTC-1-1	(4200 / 300)
	0-0.5 Ft	Demo-FWL-1	Demo-FWL-1-1	(0.3 / 9900)
	0-0.5 Ft	Demo-GPA-3	Demo-GPA-3-1	(110 / 1145.4)
	0-0.5 Ft	Demo-141DTC-7	Demo-141DTC-7	(5900 / 7400)
	4-6 Ft	SB-PIRM-119	SB-PIRM-119-2	(45 / 2351.5)

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Subarea	Depth Interval (ft bgs)	Sample Location	Sample ID	GRO / Total TPH (concentration in mg/kg)
SW-CORNER LOT	0-0.5 Ft	Demo-BS-1	Demo-BS-1	(10 / 37840)
	0-0.5 Ft	Demo-BS-2	Demo-BS-2	(1.5 / 1924)
	0-0.5 Ft	Demo-WSTPCB-3	Demo-WSTPCB-3	(<1/ 2337)
	0-0.5 Ft	SB-PIRM-98	SB-PIRM-98	(<0.13 / 1304)
UND-2	0-0.5 Ft	SB-PIRM-42	SB-PIRM-42-1	(<0.13 / 1193.2)
	4-6 Ft	SB-PIRM-42	SB-PIRM-42-2	(140 / 9450)
UND-3	0-0.5 Ft	SB-I07	SB-I07-1	(<0.17 / 30000)
		SB-PIRM-32	SB-PIRM-32-1	(<0.13 / 3200)
	4-6 Ft	SB-I07	SB-I07-2	(<0.13 / 25000)
UND-4	0-0.5 Ft	SB-L08-C	SB-L08-C-1	(<0.17 / 1700)
	4-6 Ft	SB-M06	SB-M06-2	(1 / 2501)
UND-5	0-0.5 Ft	SB-K11	SB-K11-1	(<0.15 / 4600)
		SB-K13	SB-K13-1	(<0.13 / 1800)
		SB-K14	SB-K14-1	(<0.13 / 25000)
		SB-L12	SB-L12-1	(<0.15 / 4300)
	10-12 Ft	SBD-I14-A	SBD-I14-A-2	(1300 / 3800)
		SBD-J12-C1	SBD-J12-C1-2	(4200 / 7800)
	4-6 Ft	SB-J14	SB-J14-2	(3600 / 5100)
		SB-K12	SB-K12-2	(740 / 2340)
		SB-K13	SB-K13-2	(420 / 2220)
		SB-K14	SB-K14-2	(9700 / 14200)
UND-5	4-6 Ft	SB-K15	SB-K15-2	(10000 / 47000)
		SB-L12	SB-L12-2	(13000 / 28000)
		SB-L14	SB-L14-2	(260 / 2760)
		SB-M13	SB-M13-2	(6600 / 47600)
		SB-M14	SB-M14-2	(7100 / 32100)
	5-7 Ft	SBD-I14-A	SBD-I14-A-1	(3200 / 9600)
		SBD-J12-C1	SBD-J12-C1-1	(2800 / 5300)
		SBD-J15-B	SBD-J15-B-1	(350 / 1190)
		SBD-K13-B	SBD-K13-B-1	(960 / 8560)
		SBD-M13-C1	SBD-M13-C1-1	(710 / 2110)
	8-10 Ft	SB-J14	SB-J14-3	(5900 / 15100)
		SB-K13	SB-K13-3	(140 / 4340)
		SB-K14	SB-K14-3	(14000 / 30000)
		SB-K15	SB-K15-3	(6300 / 16300)
		SB-L12	SB-L12-3	(5600 / 16600)
		SB-L14	SB-L14-3	(3700 / 12600)
		SB-M13	SB-M13-3	(5300 / 8400)
		SB-M14	SB-M14-3	(2300 / 5300)
	4-6 Ft	SB-PIRM-52	SB-PIRM-52-2	(3800 / 2391)
	4-6 Ft	SB-PIRM-55	SB-PIRM-55-2	(<0.13 / 1955.9)
	4-6 Ft	SB-PIRM-56	SB-PIRM-56-2	(2.3 / 3557)
	4-6 Ft	SB-PIRM-57	SB-PIRM-57-2	(3400 / 28300)
	4-6 Ft	SB-PIRM-58	SB-PIRM-58-2	(11000 / 29890)

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Subarea	Depth Interval (ft bgs)	Sample Location	Sample ID	GRO / Total TPH (concentration in mg/kg)
	8-10 Ft	SB-PIRM-58	SB-PIRM-58-3	(10000 / 15820)
	4-6 Ft	SB-PIRM-59	SB-PIRM-59-2	(2900 / 5778)
	8-10 Ft	SB-PIRM-60	SB-PIRM-60-3	(0.32 / 1112.6)
	4-6 Ft	SB-PIRM-63	SB-PIRM-63-2	(1100 / 32070)
	8-10 Ft	SB-PIRM-63	SB-PIRM-63-3	(5600 / 18460)

Nearly 82% of the highest concentrations of GRO- and extractable fuel hydrocarbons (EFH)-range hydrocarbons that are in excess of the SSLs are found exclusively in UND-4 and UND-5. In general, the highest total TPH concentrations were observed in the 4-6-ft interval in UND-5. Samples with SSL exceedances from UND-5 were collected in the areas with observed black carbon or other waste materials or stained soils found directly underneath the waste materials (Appendix C). Concentrations of TPH in excess of the SSL were also identified on a limited basis in the Refrigerant Plant, Phthalic Anhydride area and UND-3 within the Phthalic Anhydride Landfill area. Of the total number of samples with TPH concentrations in excess of the SSLs, GRO contributed more than 30% of the total TPH concentration in 41% of the samples. GRO was detected above the SSL of 500 mg/kg in 21 samples at 12 locations. All exceedances of the GRO SSL are found in UND-5.

2.2.1.5 Inorganics

Approximately 1066 shallow soil samples were collected from approximately 397 locations Site-wide and analyzed for a suite of inorganics during Step 1 through Step 5 activities. Based on the SSL screening evaluation process described in the Soil RI Report (Parsons 2004d), the following three inorganics had detected concentrations in excess of the SSL (SSLs in parentheses):

- Arsenic (11 mg/kg)
- Lead (750 mg/kg)
- Total Chromium (450 mg/kg)

The following table summarizes the inorganic sample results where individual COPCs were detected at concentrations in excess of the SSL.

Subarea	Depth Interval (ft bgs)	Sample Location	Sample ID	COPC (concentration in mg/kg)
BONE YARD	0-0.5 FT	SB-B14	SB-B14-1	Arsenic (19)
		SB-B15	SB-B15-1	Chromium (890)
REFRIGERANT PLANT	0-0.5 Ft	Demo-GPA-3-1	Demo-GPA-3-1-1	Arsenic (120); Antimony (520)
		Demo-OS1-1	Demo-OS1-1	Arsenic (36)
		SB-D10	SB-D10-1	Arsenic (25)
		SB-GPA-4	SB-GPA-4-1	Arsenic (13)
		SB-GPA-4	SB-GPA-4-2	Arsenic (11)
		SB-PIRM-83	SB-PIRM-83-1	Arsenic (13)

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Subarea	Depth Interval (ft bgs)	Sample Location	Sample ID	COPC (concentration in mg/kg)
		SB-PIRM-84	SB-PIRM-84-1	Arsenic (25); Antimony (580)
SW CORNER LOT	0-0.5 Ft	SB-M03	BD100903-A	Arsenic (35)
		SB-M03	SB-M03-1	Arsenic (41)
		SB-P00-A	SB-P00-A-1	Chromium (520)
		SB-P00-C2	SB-P00-C2-1	Arsenic (16), Chromium (2100), Lead 2800)
SW CORNER LOT		Demo-BP-01	Demo-BP-01-1	Arsenic (12), Lead (4600)
		Demo-SRUA-2	Demo-SRUA-2-1	Arsenic (48), Chromium (30000), Lead (4400)
		Demo-WP-EWALL	Demo-WP-EWALL	Lead (4900)
		Demo-WSTPCB-BOTTOM	Demo-WSTPCB-BOTTOM	Arsenic (11)
		SB-PIRM-94	SB-PIRM-94-1	Arsenic (14)
	4-6 Ft	SB-PIRM-94	SB-PIRM-94-2	Lead (890)
		SB-PIRM-95	SB-PIRM-95-2	Arsenic (37)
UND-2	0-0.5 FT	SB-H07	SB-H07-1	Arsenic (11)
UND-3	4-6 Ft	TB-3	TB3-UND3-5	Arsenic (16.6)
UND-3	8-10 Ft	TB-3	TB3-UND3-10	Arsenic (24.4)
UND-4	4-6 Ft	SB-M05-C4	SB-M05-C4-2	Arsenic (23)
		SB-M07	SB-M07-2	Arsenic (25)
UND-5	0-0.5 Ft	SB-J12	SB-J12-1	Arsenic (11)
		SB-K11	SB-K11-1	Arsenic (11)
		SB-L09	SB-L09-01	Arsenic (27)
		SB-L09-C	BD102803-A	Lead (970)
		SB-N15	SB-N15-1	Arsenic (12)
	4-6 Ft	SB-L09-C	SB-L09-C-2	Arsenic (11)
	8-10 Ft	SB-K13	SB-K13-3	Lead (2300)

Concentrations of arsenic in excess of the SSL are found Site-wide with the greatest frequency occurring in the SW Corner Lot, UND-3, UND-4 and UND-5 areas. The highest concentration of arsenic was observed in the SW Corner Lot in the 0-0.5 ft bgs interval. The highest concentration of both chromium and lead are found in the SW Corner Lot at location SB-P00-C2 in the 0-0.5 ft bgs interval.

2.2.2 Summary of Deep Soil Investigation Findings

The following subsections describe the nature and extent of impacted deep soil matrix at the Site. Discussions in the following subsections are limited to those COPCs that had at least one detection above the MDL at a concentration in excess of the SSL defined in the Soil RI Report (Parsons 2004d).

Data presented in this discussion include samples collected from Step 1 through Step 4 activities as well as relevant historical data. Each subsection includes a summary of all samples and results where the observed concentration for a particular COPC was detected in excess of the SSL.

2.2.2.1 VOCs

Approximately 76 deep (approximately 15 ft bgs or deeper) soil samples were collected from approximately 22 locations Site-wide during Step 1 through Step 4 activities. Based on the SSL screening evaluation presented in Section 6.2, the following three VOCs had detected concentrations in excess of the SSL (SSLs in parentheses):

- carbon tetrachloride (35 ug/kg)
- ethyl benzene (13,000 ug/kg)
- chloroform (270 ug/kg)

The following table summarizes the VOC sample results where individual COPCs were detected at concentrations in excess of the SSL.

Subarea	Depth Interval (ft bgs)	Sample Location	Sample ID	COPC (concentration in ug/kg)
PHTHALIC ANHYDRIDE	90 Ft	TB-20	TB-20-90	Carbon Tetrachloride (40)
OTHER	40-42 Ft	SBD-F13	SBD-F13-5	Chloroform (330)
		SBD-H11-C	SBD-H11-C-5	Carbon tetrachloride (260), Chloroform (1300)
UND-1	20-22 Ft	SBD-D14-A	SBD-D14-A-2	Chloroform (300)
	5-7 Ft	SBD-E13-D2	SBD-E13-D2-1	Chloroform (450)
	40-42 Ft	SBD-E13-D2	SBD-E13-D2-4	Chloroform (9600)
UND-5	20-22 Ft	TB-1	TB1-UND5-20	Ethylbenzene (39000)
	30 Ft	TB-1	TB1-UND5-30A	Ethylbenzene (90000)
	80-82 Ft	SBD-I14-A	SBD-I14-A-7	Carbon tetrachloride (860), Chloroform (270)

The highest concentrations of VOCs are found in UND-5 and consist primarily of BTEX related compounds, particularly ethylbenzene. An exception is that the highest observed concentration of chloroform in deep soil samples was found in SBD-H11-C in an area northeast of UND-3. Concentrations of carbon tetrachloride in excess of the SSL were also found in this area.

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2.2.2.2 SVOCs

Approximately 12 deep soil samples were collected from approximately six locations Site-wide during Step 1 through Step 4 activities. No SVOCs were detected at concentrations in excess of the SSL in any deep soil samples.

2.2.2.3 Pesticides/PCBs

No deep soil samples were analyzed for pesticides or PCBs during Step 1 through Step 4 or historic sampling activities. Data from shallow soil samples indicate that concentrations of pesticides and PCBs decrease with depth in the soil column and no pesticides or PCBs were detected at concentrations in excess of their respective SSL deeper than 8 ft bgs.

2.2.2.4 TPH

TPH samples were collected from eight deep sampling locations during Step 1 through Step 4 sampling activities. Only two samples, both in UND-5, had observed total TPH concentrations in excess of the SSL described in Section 6.2. Both samples were from the 15-17 ft bgs interval at locations SBD-J12-C1 (1300 mg/kg GRO / 2000 mg/kg TPH) and SBD-I14-A (260 mg/kg GRO /1560 mg/kg TPH). TPH samples from deeper than 15-17 ft bgs at both of these locations were either non-detect or less than the SSL.

2.2.2.5 Inorganics

Approximately 14 deep soil samples were collected from seven deep sampling locations and analyzed for inorganics during Step 1 through Step 4 sampling activities. No inorganics were detected at concentrations in excess of the SSL in any of the deep soil matrix samples.

2.3 COPC DISTRIBUTION IN SOIL VAPOR

The following subsections describe the nature and extent of impacted shallow and deep soil vapor at the Site (both Phase I and Phase II Redevelopment parcels). Discussions in the following subsections are limited to those COPCs that are detected in more than 2 percent of either soil or soil vapor samples and had at least one detection above the MDL at a concentration in excess of the soil vapor SSL defined in the Soil RI Report (Parsons 2004d).

Data presented in this discussion include Site-wide samples collected during Step 1 through Step 4 activities as well as relevant historical data. Each subsection includes a summary of samples and results where the observed concentration for a particular COPC was detected in excess of the SSL.

In general, carbon tetrachloride and chloroform were detected Site-wide at the greatest frequency at concentrations in excess of SSLs. Carbon tetrachloride and chloroform have two of the lowest SSLs in comparison to other COPCs. Therefore, figures referenced in the subsections below will present soil vapor data for carbon tetrachloride and chloroform in soil vapor samples, as well as total VOC concentrations in soil vapor.

2.3.1 Shallow Soil Vapor Findings

Approximately 82 shallow soil vapor samples were collected from approximately 70 locations Site-wide during Step 1 through Step 4 activities. Shallow soil vapor samples are defined as any sample collected from 5 ft bgs or less.

Per the SSL screening evaluation presented in Section 6.2, soil vapor screening levels are based on indoor air protection. The following nine VOCs had detected concentrations in excess of the soil vapor SSL (SSLs in parentheses):

- CFC-11 (230 ug/L)
- benzene (0.3 ug/L)
- bromomethane (2.9 ug/L)
- ethylbenzene (7.4 ug/L)
- carbon tetrachloride (0.2 ug/L)
- chloroform (1.5 ug/L)
- chloromethane (4.5 ug/L)
- TCE (1.4 ug/L)
- xylenes (4.1 ug/L)

A complete shallow soil vapor data summary for Step 1 through Step 4 samples can be found in the Soil RI Report (Parsons, 2004b, Table B.12 of Appendix B). Historic data summaries can be found in Appendix A of the same report.

The five highest concentrations of total VOCs in shallow soil vapor samples were observed in the Bone Yard area. The next highest total VOC concentrations occurred at three limited locations in the NE area, Refrigerant Plant, Genesolve™ Terminal, and at a location just south of UND-1. VOCs were also observed in UND-5, however, the observed total VOC concentrations were significantly lower than the maximum concentrations observed Site-wide. The distribution of the Site maximum concentrations of carbon tetrachloride and chloroform were similar to the distribution of total VOCs. The highest concentrations of carbon tetrachloride, chloroform and CFC-11 were observed in the Bone Yard. The highest concentrations of ethylbenzene and xylenes were observed in UND-5 while the highest concentrations of benzene were observed in UND-1 and UND-2.

2.3.2 Deep Soil Vapor Findings

Approximately 150 deep soil vapor samples were collected from 23 locations Site-wide during Step 1 through Step 4 activities. Deep soil vapor samples are defined as any sample collected from greater than 5 ft bgs.

Per the SSL screening evaluation process described in the Soil RI Report (Parsons 2004d), soil vapor screening levels are based on indoor air protection ESLs. The following eleven VOCs were detected in more than 2 percent of either soil or soil vapor samples and had detected concentrations in excess of the SSL (SSLs in parentheses):

- 1,1-DCE (5.1 ug/L)
- CFC-11 (230 ug/L)
- benzene (0.3 ug/L)
- bromomethane (2.9 ug/L)
- ethylbenzene (7.4 ug/L)
- carbon tetrachloride (0.2 ug/L)
- bromodichloromethane (0.2 ug/L)
- chloroform (1.5 ug/L)
- chloromethane (4.5 ug/L)
- TCE (1.4 ug/L)
- xylenes (4.1 ug/L)

A complete summary of deep soil vapor data for Step 1 through Step 4 samples can be found in the Soil RI Report (Parsons, 2004b, Table B.13 of Appendix B). Historic data summaries can be found in Appendix A of the same report.

Consistent with shallow soil vapor data, the highest total VOC concentrations in the deep soil vapor samples were observed in the Bone Yard area. The second highest total VOC concentrations were observed in UND-5. Elevated concentrations of total VOCs were also observed at the BBI Terminal and UND-1, although the total concentrations were less than those observed in the Bone Yard or UND-5. In general, total VOC concentrations increase with depth, although the highest total VOC concentration was observed at the 40-ft bgs interval at SBD-B13 (location 1D). The highest concentrations of carbon tetrachloride, chloroform and CFC-11 were observed in the Bone Yard. With the notable exception of ethylbenzene and xylenes, the concentration of individual COPCs in soil vapor increased with depth. However, the highest concentration of individual COPCs was not always observed in samples collected directly above the water table.

2.3.3 Lateral Distribution of VOCs in Soil Vapor

The lateral extent of VOCs in shallow soil vapor sampling locations where one or more COPCs were detected in excess of the SSLs is shown on Figure 2.3.1 and are identified as areas of shallow soil vapor SSL exceedance. Figure 2.3.1 shows the lateral distribution of VOCs in soil vapor from the Step 1 through Step 5 activities and relevant historic sampling events. It should be noted that significantly higher VOC concentrations were reported in the historic data than in the current data as described in Section 2.3.5. Relevant historic data are shown on the figures to represent a worst case scenario and are not likely indicative of current VOC concentrations in those areas, especially in light of on-going SVE remedial actions in certain portions of the Site.

The lateral extent of total VOC concentrations in soil vapor samples deeper than 20 ft is indicated by the soil vapor sampling results and soil vapor concentration contours on Figure 2.3.2. Coinciding maps for concentrations of carbon tetrachloride and chloroform in deep soil vapor samples (> 20 ft) are shown on Figures 2.3.3A and 2.3.3B, respectively. Separate maps were produced at a more detailed scale for the SW Corner Parcel. The lateral distribution of TCE and cis-1,2-DCE in soil vapor beneath the SW Corner Parcel is shown on two figures (Figures 2.3.4A and 2.3.4B) for the shallow and deep vadose zone, respectively.

The lateral distribution of total VOCs in shallow soil vapor is similar to the lateral distribution of total VOCs in deeper sampling intervals; although, the overall concentrations are significantly lower. The highest concentrations are observed in the vicinity of the Bone Yard, UND-1 and Phthalic Anhydride areas. A small area with elevated total VOC concentrations is also observed in UND-5. VOCs in both shallow and deep soil vapor in these areas consist mostly of fluoro- and/or chloro-compounds (CFCs, chloroform, carbon tetrachloride, etc.), consistent with expected COPCs from these areas. The lateral distribution of these COPCs, particularly carbon tetrachloride and chloroform, is similar to the distribution of the total VOC concentrations.

2.3.4 Vertical Distribution of VOCs in Soil Vapor

The vertical distribution of carbon tetrachloride and chloroform in soil vapor is illustrated on four Site cross-sections (Figures 2.3.5A-B and Figures 2.3.6A-B). Recent additional deep borings (Step 5 sampling) are also indicated on the cross sections. Data collected from these borings have been incorporated in defining the lateral and vertical extent of the VOC plume. A cross-section depicting the vertical distribution of TCE and 1,2-cis-DCE in soil vapor beneath the SW Corner Parcel is shown on Figure 2.3.7.

With few exceptions, notably in the area of the Ortho-Xylene Storage Tank area, the concentration of total VOCs in soil vapor increases with depth. Consistent with the lateral distribution of total VOCs, the highest concentrations of COPCs are found in the Bone Yard, Refrigerant Plant, Phthalic Anhydride, and Ortho-Xylene Storage tank areas. The soil vapor plume core beneath Refrigerant Plant/UND-1 has been reduced significantly by the pilot SVE system, the observed VOC distribution is indicative of an old, residual vapor plume outside the pilot SVE treatment zone.

2.3.5 Comparison of Current and Historic Soil Vapor Data

Historic soil vapor data indicate an overall average total VOC concentration of over 25,000 ug/L. In comparison, Step 1 through 5 soil vapor data indicates an overall average VOC concentration of approximately 2,100 ug/L. This represents more than an order of magnitude decrease in total VOC concentrations in Site-wide soil vapor. The highest historic concentrations were found in the Refrigerant Plant area of the Site. Current 2004 data show that concentrations in the Refrigerant Plant area have decreased dramatically due to the influence of the pilot SVE remediation in that area.

As described in previous sections, the highest current total VOC concentrations are found in the Bone Yard area where limited historical data exist. The currently detected maximum VOC concentration in the Bone Yard area is much lower than the pre-SVE VOC soil vapor concentrations detected in Refrigerant Plant area. The VOC plume in the Bone Yard area is likely a previously uncharacterized portion of the larger Refrigerant Plant plume. Elevated concentrations of total VOCs were observed in UND-5 in both current and historic data sets. The current and historic concentrations are similar, indicating VOC plume stability in this area. No SVE remediation has occurred at either the Bone Yard or the UND-5 areas that contain elevated VOC levels in soil vapor.

2.4 COPC DISTRIBUTION IN GROUNDWATER

The largest groundwater VOC plume is in the ODS Aquifer and associated with the Refrigerant Plant/UND 1 area. The Refrigerant Plant plume consists primarily of chloroform, carbon tetrachloride, and CFCs. Concentrations of chloroform, the predominant COPC, in the ODS Aquifer are shown on Figure 2.4.1 (data from the second quarter of 2004). The secondary ODS Aquifer plume consists primarily of TCE and cis-1,2-DCE and is associated with the SW Corner

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Lot area. Concentrations of TCE in the ODS Aquifer are shown on Figure 2.4.2 (data from the second quarter of 2004).

Recent concentrations of COPCs detected in the May 2004 groundwater monitoring event were generally consistent with historical monitoring data. Similar to previous observations, chloroform, carbon tetrachloride, CFCs, TCE and cis-1,2-DCE were present at the greatest frequency and concentration. The highest total VOC concentrations among the Site monitoring wells are in the ODS Aquifer beneath UND-1 just east of the Refrigerant Plant. Well AS-MW-03 has the highest total VOC concentrations among the Site monitoring wells. The highest concentrations of COPCs, with the exception of TCE and cis-1,2-DCE, are generally observed in the monitoring wells near the Refrigerant Plant for both the ODS and Gage Aquifers. The core of the Refrigerant Plant plume in the ODS Aquifer has greater that 10 mg/L of chloroform, 1 mg/L of carbon tetrachloride, and 10 mg/L of CFCs. In contrast, the highest VOC concentrations in the Gage Aquifer are several orders of magnitude lower at most locations.

The highest TCE concentrations have been detected in Old Solvents Warehouse area in wells AS-MW-19, AS-MW-18, AS-MW-23, and AS-MW-17. The core of this plume has concentrations greater than 1 mg/L TCE. The downgradient extent of the plume in off-site neighborhoods has not been fully characterized; investigation is currently ongoing.

Lower concentrations of other VOCs were detected in various wells across the Site. The highest concentrations of aromatic VOCs (primarily ethylbenzene and xylenes) were observed in AS-MW-05 and AS-MW-13; both are located in UND-5.

With few exceptions, generally decreasing total VOC concentration trends were observed in most wells. Significant fluctuations in total VOC concentrations at downgradient Gage Aquifer well AS-MW-16 continue to be observed. These variations appear to correlate with fluctuations in observed electronic conductance (EC) from this location, which is an indicator of the relative salinity of groundwater. High VOC concentration corresponds to high EC concentrations. The close correlation between VOC and EC concentrations is likely related to changes in the injection schedule of the WCBBP and winter recharge where fresh water recharge dilutes/flushes out the native saline water, which has been equilibrated with high VOCs.

Inorganic compounds (metals) in groundwater have been analyzed periodically per LARWQCB request. Consistent with historical data, the May 2004 quarterly sampling results showed detectable concentrations of various metals in all monitoring wells. Among the 18 metals analyzed in groundwater samples from the Site, the highest concentrations for most metals were detected in the ODS Aquifer wells. Beryllium, cadmium, chromium (VI), lead, mercury, vanadium and zinc were exceptions. Their highest concentrations were detected in Gage Aquifer wells.

Monitoring of the existing 21 groundwater monitoring wells for VOCs is continuing on a quarterly basis. A one year quarterly monitoring program for dissolved metals (USEPA Method 6010B) has also been planned.

As part of the ongoing site investigation/evaluation, additional monitoring wells will be installed at downgradient and off-site locations in the ODS Aquifer and Gage Aquifer. Well installations at the offsite site areas will begin when access permits are obtained from offsite property owners. These new wells will be included in the quarterly groundwater monitoring program.

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2.5 CONCEPTUAL SITE MODEL

Potential sources of COPCs in soil and groundwater at the Site are former facility operations. As discussed in the Soil RI Report (Parsons, 2004d), the source of the larger VOC vapor plume in the vicinity and downgradient of the Refrigerant Plant area is from historical release/spills on or near the land surface and the subsequent migration downward via gravity and leaching by infiltrating precipitation water. The VOC vapor plume also spread laterally due to volatilization, dispersion and diffusion. The 14,000-gallon accidental spill of chloroform that occurred in 1988 in the eastern part of the Refrigerant Plant adjacent to UND-1 is probably the main source of the observed VOC vapor plume in vadose zone soil and the dissolved VOC plume in groundwater. The spill moved as a slug and spread in all directions. Significant lateral spread occurred when the slug moved downward and reached the capillary fringe and/or relatively lower permeability zones. The result is a widespread vapor plume in the deep zone soils. Shallow soil source remedial actions were implemented shortly after the release occurred, and effectively removed the majority of the point source.

Miscellaneous undocumented leaks and spills also may have occurred in Refrigerant Plant, BBI Terminal, Old Solvents Warehouse, Xylene Tank area, Wastewater Treatment Carbon Bed Area and other areas. These potential undocumented releases could have contributed to some of the detections of TCE, PCE, CFCs, and HCFCs. The source of cis-1,2-DCE in the Old Solvents Warehouse area in the Southwest Corner Lot is likely the breakdown products from degradation of TCE. Their overall impact is relatively less significant compared with the 1988 chloroform spill.

Although the extent of the VOC vapor plume associated with the Refrigerant Plant today is similar to that which was historically delineated, the center of the plume and the magnitude of VOC vapor concentrations have significantly changed. In 1996-97, the highest total VOC vapor concentrations were on the order of 250,000 ug/L. Due mainly to the removal of more than 110,000 lbs of VOCs through the pilot SVE system in Refrigerant Plant in the last three years, the highest VOC vapor concentration beneath the Refrigerant Plant has decreased to less than 20,000 ug/L, which is an order of magnitude decrease. Vapor concentrations in other areas also decreased by at least 20 percent on average, likely due to natural attenuation processes (adsorption, leaching, diffusion, dispersion, dilution, volatilization and biodegradation).

As the center of original vapor plume core located beneath Refrigerant Plant is remediated via pilot SVE, the center of the vapor plume today has shifted from the Refrigerant Plant to the Bone Yard Area, which is just outside of the original plume core. Facility operations have ceased as of February 2003 and the facility structures have been demolished. Potential near surface COPC sources in soil are being remediated through the interim soil removal action and the deep soil vapor plume will continue to be remediated through the expansion of the SVE system. As a result, the vapor plume observed today presents the conservative, worst-case condition in considering potential current and future impacts on human health and natural resources.

Potential human health impacts from direct contact and inhalation of VOC vapors are of primary concerns for the shallow soil and soil vapor. The soil strata represent a direct, proximate source of exposure for potential receptors that might utilize the Site as redevelopment plans materialize. Indoor air could be impacted as a result of vapor intrusion from subsurface sources, while outdoor air might contain non-volatile chemicals adsorbed on fugitive dusts.

The RI indicates that surface (0- to 0.5-ft bgs) and shallow-subsurface (0- to 10-ft bgs) soils potentially contain residual VOCs and other facility-associated chemicals (Parsons, 2004b). The collection of shallow-soil VOC data from soil and soil vapor samples during the RI has demonstrated a consistent decrease in concentrations of VOC constituents. In addition, the deep-subsurface VOC slug is not thought to be a source of contamination moving upward to shallower soils.

The Site is underlain by relatively uniform dune sand extending to a depth of at least 120 ft bgs. Groundwater below the Site is encountered at between the depths of 80 ft bgs and 115 ft bgs. Close correlation of decreasing dissolved VOC concentration in groundwater with operation of nearby SVE wells indicates that the vapor plume is an active source to groundwater plume.

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3 PROPOSED SITE DEVELOPMENT

The Site is a former industrial facility proposed for commercial/industrial redevelopment. Current uses include dismantling of structures, land-clearing, and remediation activities, but these actions are not anticipated to continue for more than several months once redevelopment plans proceed. Proposed redevelopment plans for the Site include establishment of a "big box" development (large retail operations) consisting of various commercial retail buildings (e.g., home improvement center, warehouse-type discount store), smaller businesses and parking. The current conceptual development plan for the Phase I Redevelopment parcels, which include the Refrigerant Plant Parcel and the SW Corner Lot Parcel, is provided on Figure 3.1. All structures are planned to be slab-on-grade, with no subsurface features such as basements or underground parking. A deed restriction will be recorded on title. The deed restriction would prohibit residential land redevelopments such as daycare centers, churches, assisted-living centers, or residences at the Site. In addition, the surrounding land use is zoned to remain industrial and commercial, with no adjacent residential areas.

The Phase I Redevelopment Project is a component of a large development program which extends south- and eastward beyond the Honeywell property limit. A program level EIR is under preparation for the Sepulveda/Rosecrans Site Rezoning project which is a 110-acre parcel that will require a General Plan Amendment. A project level EIR concerning the Phase I Redevelopment parcels is under concurrent preparation. It addresses 38 acres of Honeywell-owned property that will be called Plaza El Segundo. *The Plaza El Segundo project is planned to open in 2006, encompass up to 425,000 ft^2 of retail businesses in the following categories: supermarket, home improvement, department store, electronics and appliances, home furnishings, pet supply, books, restaurant, and sporting goods.* (Draft Environmental Impact Report, Sepulveda/Rosecrans Site, Rezoning & Plaza El Segundo Development - Section I Introduction/Summary Page I-10). Other planned improvements include roadway extensions, a storm water retention basin, and an aquatic center.

4 FATE AND TRANSPORT OF COPCS

This section presents an evaluation of the fate and transport behavior of COPCs detected in the soil at the Site. Vadose zone modeling was used to determine site-specific soil cleanup criteria for Site-wide deep soil and soil vapor COPCs, and for post-IRM residual shallow soil impacts on the Phase I Redevelopment parcels that are protective of underlying groundwater at the Site. Evaluating the fate and transport of chemicals in surface and subsurface soils helps in assessing the potential risks and impacts on human health and the environment. Fate refers to how long a chemical will remain in the soil in its original state and the transformations it undergoes as it is traced through potential pathways. Transport refers to the physical movement of the contaminant through the air, soil, water, or biota.

4.1 NATURAL ATTENUATION

COPCs in shallow and deep vadose zone soils can exist in one of several different states: gas, liquid, pure solid, adsorbed on particulates, or in solution. Depending on their physical state and properties, these COPCs have several potential pathways.

Compounds with high vapor pressures such as VOCs may exist as gases in the soil pore air space. Compounds that are soluble in water can exist in the dissolved state in the soil pore water; or they may exist as a solid or liquid adsorbed to soil particles. Dissolved and adsorbed chemicals may also leach to groundwater. Dissolved chemicals may also degrade microbiologically.

Natural attenuation processes (biodegradation, dispersion, dilution, sorption, volatilization) affect the fate and transport of COPCs in the subsurface. When these processes are shown to be capable of attaining site-specific remediation objectives in a reasonable time period, it is reasonable to consider them as viable remedial alternatives.

Transport by leaching through the vadose zone into groundwater is considered a potential migration pathway for COPCs detected in surface and subsurface soils at the Site. As contaminants in the soil migrate through the vadose zone toward groundwater, the opportunity exists for attenuation or reduction of the concentrations of these constituents. The degree to which a contaminant concentration attenuates as it migrates in the vadose zone is affected by several processes, which include adsorption of constituents to soil particles and organic matter in the soil, ionic or covalent binding of the constituents to soil components, filtration of larger constituents by fine-grained soils, chemical or biochemical degradation, volatilization to the atmosphere or to air spaces within the unsaturated or vadose zone, and dispersion and dilution with vadose zone waters or groundwater.

Historically, no significant intrinsic biodegradation of COPCs has been observed in the vadose zone soil at the Honeywell El Segundo Site. Volatilization is a major natural attenuation mechanism for VOCs in soil. However, the most effective volatilization effects occur within the upper 10 ft of soil where the majority of evaporation occurs. Leaching, dissolution and dispersion are also important mechanisms for mobilization of COPCs. The combined effects of volatilization, leaching and dissolution/dispersion tend to result in the continued reduction of VOCs in shallow soil zone. This is consistent with the Site observations. Non-VOC COPCs are not affected by volatilization. Most COPCs (SVOCs, pesticides/PCBs, metals and certain VOCs) in Site soil have low vapor pressures and high adsorption potentials, and are mostly confined to near-surface soils. This is supported by the observed distribution of COPCs site-wide, where the majority of non-VOC COPCs are found within the upper 5 ft of soil.

4.2 SCEENING USING DESIGNATED LEVEL METHODOLOGY

A tiered approach was used to assess the potential groundwater impact due to migration of COPCs from vadose zone soil to groundwater. The tier 1 screening evaluation was performed using the Designated Level Methodology (DLM) (Marshack, 1989). The DLM calculations were used as a screening tool to narrow the list of COPCs warranting further tier 2 evaluation through VLEACH modeling. The results of the DLM application are presented in detail in Appendix A. In summary, a total of 26 organic compounds and 3 metals in 10 subareas exceed their Total Designated Level (TDL) concentrations out of the 124 initial COPCs identified in the Soil RI Report (Parsons 2004d) and listed in Table A-2 of Appendix A. According to the DLM, these COPCs are present at concentrations that may impact groundwater above action levels. Most COPCs are present in soil at the UND-4 and -5 Parcel (i.e., 20 out of 26 organics and 7 out of 8 VOCs). In contrast, COPCs that failed the DLM in subareas over the Phase I Redevelopment parcels consist mostly of SVOCs, pesticides, PCBs, and TPH (i.e., 14 out of 26 organics and 1 out of 8 VOCs). TCE at the BBI Terminal subarea is the only VOC that failed the DLM for the Phase I Redevelopment parcels.

4.3 VLEACH MODELING

Vadose zone modeling was conducted as a tier 2 evaluation to support the development of site-specific soil cleanup criteria that are protective of groundwater for Site-wide deep soil and soil vapor COPCs, and for the residual shallow soil impacts on the Phase I Redevelopment parcels. VLEACH, a vadose zone transport model that calculates the impact to groundwater of sorbed and vapor phase contaminants in the vadose zone was used for the modeling (Turin, 1990). A total of 17 soil subareas were identified from the RI Report (Parsons 2004) as targets for vadose zone transport evaluation. Table A-1 in Appendix A lists these soil subareas separated by parcels.

The objective of the VLEACH modeling was to evaluate the future impact to groundwater from COPCs in vadose soil and to establish soil cleanup levels for these COPCs to ensure compliance with applicable LARWQCB water quality goals for groundwater protection, consistent with risk-based soil remediation goals for the Site.

Based on the tier 1 DLM screening evaluation, 14 organic COPCs for the Phase I Redevelopment parcels were carried forward for VLEACH modeling and determination of soil cleanup goals for groundwater protection in these areas. The VLEACH modeling was conducted to provide a more accurate evaluation of the threat to groundwater based on their fate and transport characteristics and actual site conditions.

VLEACH input parameters consist of several types including the soil profile, the contaminant physical/chemical properties, initial contaminant concentrations, boundary conditions, and environmental parameters. A discussion of all the VLEACH input parameters and the rationale for their selection is also presented in Appendix A.

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4.3.1 VLEACH Modeling Scenarios

VLEACH was used to evaluate residual soil concentrations under two different contaminant loading scenarios:

1) Shallow Soil (0-10 ft bgs). This scenario was evaluated for all 14 COPCs that failed the DLM at subareas within the Phase I Redevelopment parcels and represents current conditions. Actual COPC concentrations detected in shallow soil samples were used in the models.

2) Deep Soil (> 10 feet bgs). This scenario was evaluated for Site-wide VOCs present in deep vadose zone soils at concentrations that could exceed groundwater quality goals. Actual vadose COPC concentrations detected in vadose zone soil or soil vapor samples were used in the models.

These scenarios were used to identify COPCs present in the soil at concentrations that would exceed groundwater quality goals. The maximum COPC concentrations detected in each depth interval sampled were used in all the evaluations. A total of 14 organic COPCs from 7 subareas of the Phase I Redevelopment parcels were targeted for shallow soil VLEACH modeling, and ten VOCs across 12 subareas Site-wide were targeted for deep soil VLEACH modeling. Detailed modeling assessment for potential impact to groundwater from COPCs in the shallow soil in the Phase II Redevelopment parcel (UND-4 and UND-5 areas) will be presented in a supplemental report that addresses the remedial actions for the shallow soil at the Phase II Redevelopment parcel.

Aquifer mixing modeling was conducted along with VLEACH to estimate the average resulting dissolved concentration of each VOC in a hypothetical extraction well located beneath the impacted soil. Backup mass balance calculations to approximate aquifer mixing for site-specific dilution attenuation factor (DAF) estimates can be found in Appendix I of the Soil RI Report for the Honeywell El Segundo Site (Parsons, 2004). These calculations estimate a DAF of 166 due to aquifer mixing in a hypothetical extraction well installed in the ODS Aquifer. This DAF was used across the board in the VLEACH modeling, to determine allowable leachate concentrations that will not cause dissolved VOC concentrations in the hypothetical extraction well to exceed groundwater quality goals for underlying groundwater at the Site.

4.3.2 VLEACH Modeling Results

The results of the VLEACH modeling for both shallow and deep soils are presented in detail in Appendix A, and briefly summarized below.

4.3.2.1 Shallow Soils

A total of 27 VLEACH evaluations were performed for the 14 organic COPCs in shallow soil that failed DLM in 7 subareas of the Phase I Redevelopment parcels, using conservative parameters. The results of these evaluations are presented in Tables A-24, A-28, A-31, A-33, A-38, A-45, and A-57 of Appendix A. The VLEACH results indicate that existing COPC concentrations meet groundwater quality goals in all 7 subareas evaluated.

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4.3.2.2 Deep Soils

A total of 40 VLEACH evaluations were performed for 8 VOCs with elevated soil or soil vapor concentrations detected in deep soil (> 10 feet bgs) using conservative parameters. The results of these evaluations are presented in Tables A-65, A-70, A-75, A-79, A-83, A-87, A-90, A-94, A-99, A-103, A-106 and A-113. The results indicate that carbon tetrachloride and chloroform are the only two VOCs that exceed their groundwater quality goals for deep VOCs. Carbon tetrachloride exceeds its groundwater quality goal at 6 subareas and chloroform exceeds it at 4 subareas, out of a total of 12 subareas evaluated. The other 7 VOCs evaluated for deep soils meet their groundwater quality goals at all subareas and do not pose a threat to groundwater.

4.4 ACTION LEVELS FOR GROUNDWATER PROTECTION

The VLEACH modeling results show that at the completion of the ongoing shallow soil hot spot removal action, residual levels of COPCs in all shallow soil on the Phase I Redevelopment parcels will not pose a threat to groundwater. Potential impact from the shallow soil vapor on groundwater was also evaluated. The shallow soil vapor levels estimated to be protective of groundwater are compared with the corresponding risk-based action levels for indoor air protection (Section 5) and the more stringent of the two are proposed as the final action levels for the shallow soil vapor.

For COPCs in deep soil and soil vapor, VLEACH evaluations were performed for 8 deep soil and soil vapor COPCs, to establish average site-specific soil and soil vapor cleanup levels for each COPC that would meet groundwater quality goals. The 8 COPCs were selected based on their high frequency of detection in deep soil and soil vapor and their relatively high concentrations compared with the corresponding water quality goals. These COPCs and their resulting soil and soil vapor cleanup levels for deep soil are summarized in Table 4.1. Among the 8 COPCs for which additional VLEACH modeling was performed, carbon tetrachloride and chloroform are the only two COPCs that could potentially cause unacceptable impacts on groundwater. These results serve as the basis for establishing action levels for the deep soil and soil vapor (Section 6).

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5 HUMAN HEALTH RISK ASSESSMENT

A site-specific risk assessment was conducted to provide estimates of potential risks and hazards to human health associated with site-related chemicals detected in sampled locations of shallow (0- to 10-feet ft bgs) soil at the El Segundo Site in support of site assessment, interim remedial measures, and the RAP for soil at the Site.

As presented in USEPA guidance documents, human health risk assessment is a four-step evaluation process that includes:

- Data collection/evaluation and identification of COPCs (*i.e.*, hazard identification);
- Exposure assessment;
- Toxicity assessment; and
- Risk characterization.

Each of these steps is discussed in detail below.

5.1 DATA COLLECTION/EVALUATION AND IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN (COPCS)

Per USEPA (1989) risk-assessment guidance, the data collection/evaluation step involves collecting and reviewing all relevant site data and identifying COPCs (*i.e.*, chemicals with a potential to pose unacceptable risks/hazards to the identified receptors). The steps involved in data collection have been discussed previously in the Soil RI Report and its addendum (Parsons, 2004d,f). The primary data-evaluation steps include 1) a review of site characterization information; 2) a refinement of the preliminary conceptual site model; 3) an evaluation of analytical data for usability in risk assessment; and 4) the identification of COPCs.

For purposes of the risk assessment, the initial roster of COPCs included any chemical detected in soil or soil-vapor samples collected during the RI. As summarized in the Risk Assessment (see Table 1, Appendix B), 63 volatile organic compounds (VOCs), 30 semivolatile organic compounds (SVOCs), 20 pesticides, 4 polychlorinated biphenyls (PCBs, commonly called "Aroclors" [a trade name]), dioxin and furans, and 19 inorganics were detected.

5.2 EXPOSURE ASSESSMENT

The objective of the exposure assessment is to estimate the type and magnitude of potential exposures to Site COPCs. The results of the exposure assessment are combined with results from the toxicity assessment (see Section 5.3) to characterize potential risks (see Section 5.4). Per USEPA (1989), exposure assessment is a three-step process involving characterization of the exposure setting, identification of exposure pathways, and quantification of exposure.

5.2.1 Exposure Setting and Exposure Pathways

The exposure setting and exposure pathways are best summarized in a Conceptual Site Model (CSM). The purpose of a CSM is to aid in understanding and describing a site and to present risk assessment assumptions regarding:

- Suspected sources and types of contaminants present;

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- Contaminant release and transport mechanisms;
- Affected media;
- Potential receptors that could contact site-related contaminants in affected media under current or future land-use scenarios; and
- Potential routes of exposure.

The CSM for the Site is presented in Figure 5.2.1, and discussed in the following text.

5.2.1.1 Potential Sources, Release and Transport Mechanisms, and Affected Media

Sources of potential contamination are related to facility operations, including UNDs and structures. At least one documented spill of chloroform occurred from the Refrigerant Plant, and was considered a major source for the VOC vapor and groundwater plumes present beneath the Refrigerant Plant, UND-1, and the surrounding areas (OHM, 1989; URS, 1995). Miscellaneous undocumented leaks and spills may have also occurred in the Refrigerant Plant, BBI Terminal, and other areas. Those could have contributed to some of the detections of TCE, PCE, CFCs, and HCFCs in these areas. As developed in the RI (Parsons, 2004d,f), the likely overall impact of these undocumented contributors is relatively minor compared to the large spill of chloroform.

The RI (Parsons, 2004d,f) indicates that surface (0- to 0.5-ft bgs) and shallow-subsurface (0- to 10-ft bgs) soils potentially contain residual VOCs and other site-related chemicals. As developed in the RI, the collection of shallow-soil VOC data from soil matrix and from soil vapor has demonstrated a consistent decline in concentrations of VOC constituents over the time. In addition, there is a deep-subsurface VOC slug, a residual VOC vapor-plume that has migrated downward from historical releases and spills at the surface, but it is not a source of contamination moving upward to shallower soils. This is evident from the observed rapid reduction in VOC concentrations in groundwater shortly after the operation of the nearby SVE wells. Hence, the focus of the risk assessment and the soil removal action as described in the *Revised IRM WP* (Parsons, 2004b) is on the surface and shallow-subsurface soils. These soil strata represent a direct, proximate source of exposure for potential receptors that might utilize the Site as redevelopment plans materialize.

The Site is underlain by relatively uniform dune sand extending to a depth of at least 120-ft bgs. Groundwater below the Site is encountered at approximately 80-ft bgs or greater. Groundwater beneath the Site is not suitable for drinking water due to historically high salt content (resulting from seawater intrusion). The focus of this report is analysis of surface and shallow-subsurface soils. The potential for deep-subsurface VOCs to affect groundwater are addressed in the fate and transport analysis in Section 4.

Indoor air and outdoor air are also potentially affected media. Primarily, outdoor air would convey non-volatile chemicals adsorbed on fugitive dusts to potential receptors whereas indoor air might primarily contain VOCs in (future) building spaces resulting from vapor intrusion from subsurface sources.

5.2.1.2 Anticipated Land-Use

An integral part a site-specific risk assessment is the development of exposure scenarios appropriate for the current and future use of the Site. The presumed land use evaluated in a risk

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assessment determines which risk management options can be proposed (*e.g.*, no further action [NFA], deed restrictions, post-closure care, monitoring, *etc.*). Given that land use is a factor in determining the frequency and magnitude of human exposure, and land use(s) at the Site may vary, it is necessary to characterize current and future land use.

The Site is a former industrial facility proposed for commercial/industrial redevelopment. As such, recent uses included dismantling of structures, land-clearing, and remediation activities. At present, the Site surface has been cleared of all structures, and IRM activities are, or have, occurred at hot-spot locations. Redevelopment plans for the Site are directed towards establishment of a "big box" development (large retail operations) consisting of various commercial retail buildings (e.g., home improvement center, warehouse-type discount store, *etc.*), smaller businesses, and parking. Tentative site-layouts of the redevelopment plan are displayed in Figure 3.1. All structures are planned as slab-on-grade, with no subsurface features (basements or underground parking). A deed restriction will be recorded on title, and no development will ever include residential land redevelopments such as daycare centers, churches, assisted-living centers, or residences. In addition, the surrounding land use is zoned to remain industrial and commercial, with no adjacent residential areas.

5.2.1.3 Potential Receptors

Potential receptors are defined as humans that may contact (*i.e.*, be exposed to) site-related chemicals in environmental media. Consistent with USEPA (1989, 1995) guidance, and as an outcome on ongoing consultations with the LARWQCB, current and reasonably anticipated future land use were considered when selecting potential receptors, and include:

- **Outdoor Non-Intrusive Worker** – for example, a future landscaping worker or a current grading contractor who *is not* engaged in intrusive activities (*i.e.*, digging into soil). This receptor may potentially be exposed via incidental ingestion, inhalation, or dermal contact with COPCs in surface soil (0- to 0.5-ft bgs). Surface soils could be present during Site redevelopment, or at exposed landscape features (*e.g.*, planted areas or small "open space" greenbelts) that may be part of the developed landscape in the future.

- **Excavation Worker** – for example, a future utility-line worker or a current grading contractor who *is* engaged in intrusive activities (*i.e.*, digging into soil). This receptor may potentially be exposed via incidental ingestion, inhalation, or dermal contact with all types of COPCs in soil (VOCs, pesticides, inorganics, *etc.*). The Excavation Worker receptor is hypothesized to contact surface (0- to 0.5-ft bgs) and shallow-subsurface (0.5- to 10-ft bgs) soils at the Site.

- **Child Shopper** – for example, a teenager that regularly socializes at the indoor retail facilities. Although a teenaged child is a more-likely example of this receptor, the exposure estimates will be based on values for a toddler-aged child (see Section 6.2 of Appendix B) as a health-protective (conservative) assumption. This hypothetical receptor may potentially be exposed via inhalation to VOCs in indoor air which emanate from soil or soil vapor under the building in which this receptor socializes.

- **Indoor Worker** – for example, a future worker in the retail facilities. This hypothetical receptor may potentially be exposed via inhalation to VOCs in indoor air

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which emanate from soil or soil vapor under the building in which this receptor works.

5.2.1.4 Exposure Pathways

An exposure pathway is the course a chemical agent takes from a source to a receptor, and is a unique mechanism through which an individual is exposed to chemicals at, or originating from, a site. Each exposure pathway includes a source or release from a source, an exposure-point location, and an exposure route. If the exposure-point location differs from the source location, a transport mechanism or a movable exposure medium (*e.g.*, air or water) also is involved. Site-related sources, types of environmental releases, and potential receptors and activity patterns determine the significant pathways of concern and those which are incomplete or insignificant (*i.e.*, there is no connection, or a minor connection, between the source and the receptor).

5.2.1.4.1 Soil

Soil represents a source of, and a transport medium for, Site-related chemicals. Potential release mechanisms for contaminants in surface and shallow-subsurface soil include tracking, excavation, fugitive dust generation, volatilization, and uptake from skin ("dermal contact").

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emanate into outdoor air would dilute to concentrations markedly less than that experienced by the Outdoor Non-Intrusive Worker or Excavation Worker receptors.

5.2.1.4.3 Indoor Air

Site-related VOCs may migrate into soil pore-space and then into structures (via, for example, cracks in a foundation). Receptors may be exposed to contaminants via inhalation of VOCs in indoor air, and include:

- **Indoor Worker and Child Shopper:** Exposed to VOCs via *inhalation of indoor air* containing VOCs that have volatilized from surface or shallow-subsurface soil vapor and/or soil into indoor air.
- **Outdoor Non-Intrusive Worker and Excavation Worker:** No complete pathways for exposure, as these receptors are not hypothesized to be present in indoor settings during their Site-related activity patterns.

5.2.1.4.4 Groundwater

Groundwater below the Site is encountered at approximately 80-ft bgs or deeper, but is not suitable for drinking-water uses due to historically high salt content (resulting from seawater intrusion). However, fate and transport modeling has been conducted to address the impact to groundwater (See Section 4). The remaining concern is the potential volatilization of VOCs from groundwater to vadose soil, and further migration from vadose soil to indoor and outdoor air, to affect indoor and outdoor receptors. Although it is a problem for sites with shallow water table, the depth at which groundwater occurs under the El Segundo Site is nearly deep-enough to permit the elimination of groundwater as a potential source of volatile chemicals to affect indoor and outdoor receptors. USEPA's (2002) *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils* guidance document states that the vapor intrusion pathway is not an issue at most sites if the contamination is located ≥100 ft away (horizontally and/or vertically). In addition, concentrations of VOCs in the subsurface are greater in the vadose zone than in the deeper-occurring groundwater (see Section 5.2.1.1 discussion of the source of vadose-zone VOCs). The depth-to-groundwater at the Site, the lack of direct use of groundwater for drinking or household/commercial use, and the relatively greater potential source of VOCs in vadose-zone soil precludes complete or significant pathways for exposure of Site receptors to groundwater (or chemicals in groundwater).

The LARWQCB *Interim Site Assessment and Cleanup Guidebook* (LARWQCB 1996) presents detailed requirements for evaluation and determination of the potential threat to the groundwater resource from (Site-related) chemicals. Site-specific cleanup goals for groundwater protection were addressed in Section 4, primarily by a fate and transport analysis. Ultimately, the final remedial action objective(s) developed for Site soil will involve consideration of the more-stringent guideline of either the (1) health-risk-based cleanup objective, or (2), the groundwater-protection objective.

5.2.2 Quantifying Exposure

Exposure is a function of the concentration of chemical in an environmental medium (*e.g.*, soil) and receptor-specific exposure characteristics (*e.g.*, intake rate, body weight, exposure frequency, *etc.*):

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$$Estimated\ Exposure = f(media\ concentration, exposure\text{-}parameter\ values) \quad (1)$$

Quantification of exposure involves quantifying the magnitude, frequency, and duration of exposure for the receptors and exposure pathways of concern. Following is a list of the potential exposure pathways that were considered for the Site:

- Incidental ingestion of soil;
- Dermal contact with soils;
- Inhalation of dust particles from soil;
- Inhalation of chemicals volatilized from soil into outdoor air; and
- Inhalation of chemicals volatilized from soil or from soil vapor into indoor air.

The specific methods and exposure-parameter values used to estimate exposure via each of these exposure pathways were detailed in Section 6.2 of Appendix B, and are not repeated herein.

5.3 TOXICITY ASSESSMENT

In order to evaluate the risks/hazards associated with potential exposure to COPCs at a site, the types of health effects that may result from exposure to each COPC and the quantitative relationship between the amount of exposure and the extent of potential effects must be identified. Per USEPA (1989), the toxicity assessment step includes the identification of appropriate exposure periods (*e.g.*, chronic) and the determination of carcinogenic and noncarcinogenic toxicity factors (as appropriate for a specific chemical). The objectives of the toxicity assessment are to document the available toxicological evidence which quantifies the relationship between the exposure to a chemical and the increased likelihood and/or severity of adverse effects.

The methodologies used to develop toxicity factors differ, depending on whether the COPC is a potential carcinogen (produces tumors) or a non-carcinogen (produces adverse health effects such as liver toxicity, kidney toxicity, neurotoxicity, *etc.*). The most recently available toxicity factors were obtained from standard sources (indicated in order of preference):

- The California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (OEHHA, 2004);
- The USEPA's *Integrated Risk Information System* (IRIS; USEPA, 2004);
- The USEPA's Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997a);
- Toxicity values from the National Center for Exposure Assessment (NCEA), as presented in the Preliminary Remediation Goal (PRG) documentation from USEPA Region 9 (2002).

Oral toxicity values reflect administered-dose values, which represent concentrations that will be protective following ingestion. Inhalation toxicity values are representative air concentrations that will be protective following inhalation (24 hours/day). The dermal route of exposure, however, evaluates the toxicity of concentrations of chemicals in the blood (absorbed dose). Therefore, the absorbed-dose concentrations identified for dermal exposure must be compared to toxicity values adjusted for gastrointestinal absorption. Toxicity values adjusted for gastrointestinal absorption are derived by applying oral absorption factors to administered-dose toxicity values. Details are provided in Appendix B.

5.4 RISK CHARACTERIZATION

The purpose of the risk characterization step is to 1) integrate the results from the exposure and toxicity assessments; 2) quantitatively estimate the potential for cancer (i.e., risk) and non-cancer (*i.e.*, hazard) effects; and 3) assess and discuss uncertainties associated with all the risk assessment steps. These processes are summarized below (see Appendix B for details), followed by a summarization of the risk-assessment results for the shallow-soil RI.

5.4.1 Risk Estimation

To characterize potential non-carcinogenic effects, comparisons were made between estimated exposures to COPCs and the COPC's respective toxicity value(s). To characterize potential carcinogenic effects, the incremental probability of an individual developing cancer over a lifetime will be calculated from estimated exposure levels and chemical-specific dose–response information (*i.e.*, carcinogenic toxicity factors). Cancer risks for carcinogens, and hazard quotients (HQs) for non-carcinogens, are calculated (for each COPC having available toxicity factors) according to:

$$Cancer\ Risk = Exposure\ Estimate \times Cancer\ Slope\ Factor \qquad (2)$$

where:

Cancer Risk = increased probability of developing cancer in a lifetime as a result of the Site-specific exposure (dimensionless);

Exposure Estimate = Predicted exposure for a specific receptor (milligram [mg] COPC per kilogram body weight [kg_{BW}] per day; "mg/kg_{BW}–day"); and

Cancer Slope Factor = Quantitative toxicity value [$(mg/kg_{BW}\text{–day})^{-1}$];

and:

$$Noncancer\ Hazard\ Quotient\ (HQ) = Exposure\ Estimate / Reference\ Dose \qquad (3)$$

where:

HQ = Exposure:toxicity ratio (dimensionless);

Exposure Estimate = Predicted exposure for a specific receptor (mg/kg_{BW}–day); and

Reference Dose = Quantitative toxicity value $(mg/kg_{BW}\text{–day})^{-1}$.

The HQ approach assumes that there is a level of exposure (*i.e.*, the toxicity value) below which it is unlikely that even sensitive populations would experience adverse health effects. If the exposure level exceeds the threshold (*i.e.*, if HQ exceeds unity), there may be concern for potential noncancer effects. Per USEPA (1989), the greater the HQ above unity, the greater the level of potential concern.

5.4.2 Cumulative Effects

Summations of risk estimates or HQs are used to assess the overall potential for adverse health-effects posed by more than one exposure route and more than one chemical (*i.e.*, cumulative hazards from exposure to multiple COPCs via multiple exposure routes). These summations are referred to as hazard indices (HIs).

5.4.3 Uncertainties

Risk assessment is, in general, an intrinsically uncertain process in that it requires utilization of assumptions about exposure and toxicity because comprehensive site-specific data are rarely available. However, when risk assessment is conducted using agency guidance and agency-approved processes (as herein), those aspects of uncertainty become understood and accepted parts of the analysis. Because the Unit Concentration Approach used in the risk assessment (see Appendix B) is primarily a theoretical exercise and is not reliant to a great degree on site-specific data, the primary uncertainties are those general uncertainties about exposure and toxicity that are inherent in any risk assessment process. For example, have exposure scenarios been properly defined and do exposure-parameter values present a reasonable approximation of reality (or a future reality)? Although there is ultimately uncertainty in the process, risk-assessment is a sufficiently certain process to support remedial decision-making.

The greatest site-specific uncertainty is whether the chemical-characterization data are adequate and sufficient. At the completion of the five RI steps and submission of the final RI report (Parsons, 2004f), the RI has completed all characterizations requested by the LARWQCB and it is assumed that the characterization is complete. To this point in this report, all chemical-concentration data obtained during the five steps of the RI (Parsons, 2004d,f) were used to provide a roster of chemicals to evaluate in the Unit Concentration Approach. The chemicals evaluated herein are a robust, diverse set, covering all typical types of chemical pollutants. The Unit Concentration Approach used a health-protective (conservative) assumption that any detected chemical should be evaluated, *e.g.*, even those with only one detected concentration in the several hundreds of samples that have been collected at the Site. Thus, 63 VOCs, 30 SVOCs, 20 pesticides, 4 PCBs, dioxin, and 19 inorganics were evaluated through the process. This helps to ensure that potential risks to human health are not overlooked.

Toxicity data were not available (and unit-concentration values could not be derived) for ten VOCs (4-chlorotoluene, chlorotrifluoroethene, 1,1-dichloro-1-fluoroethane, dichlorofluoromethane, 1,1-dichloropropene, 2-hexanone, *p*-isopropyltoluene, 2-methylheptane, octane, and 1,2,3-trichlorobenzene), and one pesticide (delta-BHC). This contributes to some uncertainty in the cumulative risk estimates, but is an unavoidable consequence of a lack of toxicological data.

5.4.4 Risk-Management Targets

The USEPA's risk-management range for theoretical incremental cancer risk (probability of developing cancer) is 1×10^{-4} to 1×10^{-6}. Exposure concentrations resulting in a theoretical cancer-risk estimate greater than 1×10^{-4} generally warrant remediation under any land-use setting, while exposure concentrations resulting in a theoretical cancer-risk estimate less than 1×10^{-6} constitute a *de minimis* (insignificant) risk and would be suitable for unrestricted land uses. In industrial settings, target values for hypothetical cancer risk are commonly set at the 1×10^{-4} level.

In accordance with the OEHHA's recommendations (agency comments provided October 16, 2003 and November 14, 2003), the final decisions for soil closure will be based on cumulative risks and total hazard indices for an exposure area:

- Cumulative theoretical cancer-risk target level: 1×10^{-5}

- Target HI for chronic noncancer effects: 1

5.5 RISK ASSESSMENT RESULTS

Results of the risk assessment are presented for three general categories: the shallow-soil RI data, Step-5 data, and Site-wide soil-vapor data.

5.5.1 Shallow-Soil RI

The RI Reports (Parsons, 2004d,f) provides documentation of the extensive data-collection efforts for Site characterization. The basic chemical-concentration results were then screened against a first tier of a suite of values to evaluate whether the measured concentrations of chemicals at a location exceeded certain risk-management indicators:

- USEPA Region 9 Preliminary Remediation Goals (PRGs) developed by USEPA Region 9 (2002);
- Environmental Screening Levels (ESLs) developed by the San Francisco Regional Water Quality Control Board (SFRWQCB, 2003);
- Screening Levels for Protection of Groundwater (LARWQCB, 1996);
- Total Designated Levels (TDLs) generated using Designation Level Methodology (DLM) Methodology for Protection of Groundwater (Marshack, 1989);
- Background concentrations for inorganics (detailed in the RI; Parsons, 2004d); and
- Screening-levels for Total Petroleum Hydrocarbons (LARWQCB, 1996).

Locations with chemical concentrations that exceeded the most stringent of any of these indicators were identified as *potential* "hot-spot" locations. Forty-six potential hot-spot locations are identified in the RI (Parsons, 2004f). Forty-three were located on Phase I parcels and three on Phase II parcels. For the forty-three potential hot spots located on the Phase I parcels, a location-specific risk assessment (second tier evaluation) was performed to determine whether IRMs are warranted at these potential hot-spot locations. Those potential hot-spot locations that failed the second-tier evaluation are the targets of executed, ongoing, and planned IRMs to remove contamination to levels below the risk-management targets. Confirmation of compliance with the risk-management goals will be documented in the *IRM Completion Report* (*to be prepared* upon completion of the IRMs). The *IRM Completion Report* will also include a final risk assessment evaluating all available data from RI and confirmation sampling of shallow soil, but excluding data from hot-spot locations that have been removed during the IRMs.

5.5.2 Step 5 RI Data

As noted in previous sections and outlined in the LARWQCB-approved *Revised IRM WP*, a tiered risk assessment has been performed for all RI data. The first-tier evaluation was a screening process conducted as part of the RI, and used a set of conservative SSLs to screen for potential hot spots. As presented in the RI Report (Parsons 2004d,f), no further evaluation is necessary for locations where COPC concentrations are less than SSLs. Similarly, COPC concentrations greater than SSLs would indicate that the location warranted further assessment by a location-specific risk assessment (*i.e.*, the second-tier evaluation). Locations requiring a site-specific risk assessment (the second-tier evaluation) were identified as potential hot spots in the RI report. A second-tier evaluation was completed for all RI potential hot spots identified by the first-tier screening.

The first step of the second-tier evaluation consisted of conducting sample-specific risk assessments in accordance with the procedures and plans presented in the LARWQCB conditionally approved risk assessment report ("*Revised Goals Report*" – Parsons, 2004c). Locations that were identified as potential hot spots in the first-tier screening, but with a cumulative risk less than 10^{-5} and an HI less than 1 in the second-tier evaluation, were eliminated from further consideration as hot spots. IRM soil-removal actions are being taken for those hot spots with cumulative risks exceeding 10^{-5} or an HI>1 for organics or with concentrations exceeding background for certain inorganics. The second-tier evaluation considered background concentrations of inorganics, and eliminated locations where cumulative risks were driven primarily by inorganics at concentrations below their background levels.

In the *Revised Goals Report* and *Revised IRM WP* (Parsons, 2004c,b), second-tier evaluations (location-specific risk assessments) were performed for 20 potential shallow soil and soil vapor hot spots identified by the first-tier evaluation in the Soil RI Report (Parsons, 2004d). The Soil RI Report included data collected during Steps 1 through 4. Based on the second-tier risk assessments for 17 locations located on Phase I Redevelopment parcels, 8 locations were recommended for IRM soil removal action because either (a) the cumulative risk exceeded 10^{-5} or the HI was greater than 1, or (b) inorganic concentrations (i.e., arsenic) exceeded their background levels. Other potential hot spot locations identified initially during the conservative RI screening were not recommended for IRM soil removal action because they either do not pose unacceptable risk (based on second-tier risk assessments) or the risk-driver chemicals were detected primarily in soil vapor such that IRM removal action is not an effective remediation.

During the Step-5 RI, 26 additional potential shallow-soil hot spots were identified during the first-tier evaluation (Parsons, 2004f). Of the 26 locations identified as potential hot spots in the RI's first-tier screening, second-tier risk assessment was performed for 25 locations (risk assessment was not performed for location "Refrigerant Plant E08B" because it was a hot spot based only on TPH exceedances). For each of the 25 locations, location-specific risk assessments (the second tier of evaluation) were performed following the same procedure outlined in the *Revised Goals Report* and the *Revised IRM WP* (Parsons, 2004c,b). The results are presented in Tables 5.1 and in Appendix B. Of the 25 potential hot spots for which the second-tier risk assessment was performed, 11 were recommended for IRM soil-removal action because either the cumulative risk exceeded 10^{-5} or the HI was greater than 1, or inorganic concentrations (arsenic) exceeded their background levels. Tables 5.2A and 5.2B summarize the second-tier risk assessment results for potential hot spots identified during RI Steps 1 through 4 and during Step 5, respectively. Further discussions of the IRM implementation for those hot spots are presented in Section 6 and Section 8 of the RAP.

At the completion of the IRM soil-removal action, a final risk assessment will be conducted for the shallow soils on the Phase I Redevelopment parcels using all residual soil concentration data to confirm that the IRM hot-spot soil-removal actions have effectively remediated all concentrations of COPCs in shallow soil to levels below the risk-management targets (cumulative risks less than 10^{-5} and HI less than 1). This final risk assessment will use all RI and confirmation soil-sampling data with the exception of those from locations that have been removed as part of the IRM soil-removal action. This final risk assessment will be presented as

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part of the *IRM Completion Report*. With the removal of soil hot spots in accordance with the *Revised IRM WP*, the cumulative risks will be below the risk-management target values for cumulative risk (i.e., $\leq 10^{-5}$) or cumulative hazard (HI$\leq$1) or background for inorganics for all sampling locations on the Phase I Redevelopment parcels. Therefore, completion of the ongoing IRM shallow-soil hot-spots removal actions will complete the required remediation action for the shallow soil, with the exception of the VOC soil-vapor plumes (for which a remedial action plan is developed in this RAP with details presented in the following Sections 6 through 9).

It should be noted that the second-tier risk evaluation has only been conducted for the potential hot spots on the Phase I Redevelopment parcels. A separate RAP including a risk assessment report will be submitted in the future for the *shallow soil* for the Phase II parcels.

5.5.3 Sitewide Soil-Vapor Data

Risk and hazard estimates for all shallow soil-vapor locations sampled through Step 5 of the RI are provided in Table 5.3. This table excludes those locations that have been or will be removed as part of the ongoing IRM soil-removal actions. Although UND-4 and UND-5 are not part of the Phase I Redevelopment parcels, soil vapor data are included herein because this RAP addresses the soil-vapor issues on a Site-wide basis.

As indicated in the summary table, cumulative risk levels at many locations are above the risk-management target values for cumulative risk (*i.e.*, $>10^{-5}$) or cumulative hazard (HI>1) and remedial actions may be considered. Figure 5.2.2 shows the areas where the cumulative risk level exceeds the target risk management level for the following exposure scenarios:

- Indoor Worker exposed to VOC vapors volatilizing from the subsurface soil into indoor air.

It is noteworthy that in all cases, estimated cumulative risks for the Indoor Worker are consistently higher than those for the Child Shopper. Comparing the risks using soil-vapor data from multiple depths, the soil-vapor data from 4- to 6-ft bgs depth lead to higher estimated risks than do the concentrations at the 8- to 10-ft bgs depth.

6 REMEDIAL ACTION OBJECTIVES AND ACTION LEVELS

Remedial action objectives (RAOs) for soil and soil vapor are described in this section. From these RAOs, remedial action levels have been developed for Site soils and soil vapor, and are also presented in this section. Issues concerning groundwater cleanup and groundwater RAOs will be addressed in a separate RAP for groundwater that is currently being developed.

6.1 REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) have been developed for the Site to protect human health and the environment. The RAOs for shallow hot-spot removal were presented in the IRM Work Plan (Parsons, 2004b). Additional RAOs have been developed for deep soil and presented in this RAP. The RAOs for the Site soils are summarized as:

1) Protect human health by reducing the risks associated with (a) direct contact with contaminated soils, and (b) potential inhalation of vapors and dusts in indoor and outdoor air from COPCs in shallow soils; and

2) Prevent degradation of groundwater by removing COPCs from deep soils.

Remedial actions should take place in such a way and in a timeframe to not impede property development, but instead allow development to proceed safely and efficiently.

6.2 ACTION LEVELS FOR SOIL

As presented in the RAOs above, action levels must be developed for (a) shallow soils (less than 10 ft bgs) to prevent direct contact exposures, and (2) deep soils to prevent further degradation of groundwater.

Risked-Based Action Levels for Shallow Soil

A tiered approach was used to screen for potential soil hot spots where remedial action may be required. Tier 1 screening was conducted as part of the remedial investigation (RI) using a set conservative soil screening levels (SSLs). Forty-six locations were identified through RI screening as potential hot spots (Table 2.2.1 and Figure 2.2.1). Risk assessment was performed in the Tier 2 evaluation for any potential soil hot spot that fails the Tier 1 RI SSL screening. Soils failed to pass the risk assessment were recommended for remedial action as part of the soil IRM. This approach was well documented in LARWQCB approved IRM Work Plan (Parsons, 2004b).

Section 5 presented the human health risks associated with direct contact with impacted soil and inhalation of vapors and dusts in indoor and outdoor air. Site-specific risk and hazard estimates per unit concentration of each COPC were presented. These estimates were used as the basis to calculate the excess cumulative risk for each potential hot spot. From these, shallow soil IRM cleanup goals were developed based on the cumulative risk level of 10^{-5} and total hazard quotient of 1. The target cumulative risk of 10^{-5} and hazard quotient of 1 are generally considered acceptable by USEPA for risk management decisions for industrial land use.

Soil excavation and removal was conducted as part of the IRM to remediate shallow soil hot-spots in accordance with the LARWQCB-approved *Revised IRM WP* (Parsons, 2004b). It should be noted that recent IRM actions focused solely on Phase I Redevelopment parcels that only include the Refrigerant Plant and SW Corner Lot parcels. The Phase II Redevelopment parcel (UND-4 and UND-5 areas) will be addressed separately.

Arsenic is a naturally occurring compound in the region and present in all samples across the Site. Because of its toxicity characteristics, it contributes a significant amount of risk to each hot spot location even at concentrations below the regional background concentration of 11 mg/kg. Therefore, a presumptive decision was made to adopt the background concentration of 11 mg/kg as the cleanup goal for arsenic.

In summary, two criteria or action levels were used to make IRM soil removal action decisions:

- Excess site-attributable risk (cumulative risk exceeds 10^{-5} or cumulative HI exceeds 1) from COPCs in soil, and
- Arsenic at concentrations greater than the background concentration of 11 mg/kg.

Using these action levels, impacted soil that would potentially pose an unacceptable risk by direct contact was removed during the IRM implementation. Note that the LARWQCB screening level for TPH was also considered as a criterion in the *Revised IRM WP*. Per discussions during the July 13, 2004 meeting with LARWQCB, TPH screening level should not be considered a criterion for remedial action because specific analytical parameters including VOCs, SVOCs, metals and pesticides/PCBs have been analyzed for samples with elevated TPH levels and concentrations of these chemicals have been included in the RI screening and risk assessment.

Because the number of chemicals detected and the concentration level of each chemical vary from location to location, RBCGs are developed for each hot spot. As such the IRM action levels (i.e. RBCGs) for soil are location specific. Specific details for the calculation of location-specific RBCGs are presented in the *Revised Goals Report* (Parsons, 2004c) for potential hot spots identified during the Steps 1 through 4 RI and in the upcoming IRM completion report for additional hot spots identified during the Step 5 RI. The risk assessment presented in Appendix B and the summaries presented in Section 5 of this report show that completion of the ongoing IRM hot spot removal action eliminates all unacceptable direct contact risks from the shallow soil for all Phase I parcels.

Soil Action Levels Protective of Groundwater

The fate and transport evaluation presented in Section 4 of this RAP identified deep soil VOC concentrations that would impact groundwater above water quality objectives. Action levels for the deep soil are summarized in Table 4.1. Cleanup of this soil will be addressed through the remedial actions proposed to cleanup the soil vapor plume discussed in Section 6.3 and in Section 9. Because there are predominantly sandy soils present at the Site, achievement of the soil vapor action levels described in Section 6.3 should also meet soil action levels.

For the shallow soil (<10 ft), the fate and transport evaluation using the RWQCB Designated Level Methodology (DLM) (RWQCB, 1989) approach has shown that the risked-based action levels are more stringent than the action levels protective of groundwater for all Phase I parcels. Hence, completion of the shallow soil hot spot removal action in accordance with the risked-based action levels will meet the cleanup goals for groundwater protection for all shallow soils through out of the Phase I parcels.

6.3 ACTION LEVELS FOR SOIL VAPOR

As presented in the RAOs above, soil vapor action levels must be developed both (a) to prevent inhalation of unhealthful levels of vapors and dusts in indoor and outdoor air stemming from shallow soils and (b) to protect further degradation of groundwater.

Risked-Based Action Levels for Shallow Soil Vapor

As with the soil IRM, the action levels for soil vapor are based on an inhalation exposure pathway, are site-specific and are derived from the suite of COPCs found at each location (Section 5). The soil vapor action levels are based on the *cumulative* risk level of 10^{-5} and *total* hazard quotient of 1, in order to avoid "over remediation" (excessive commitment of resources for marginal benefit) and to minimize "under remediation" (inefficient use of resources if additional remediation will be required). The target cumulative risk of 10^{-5} and hazard quotient of 1 are generally considered acceptable by USEPA for risk management decisions for industrial land use. Figure 5.2.2 shows the areas where the cumulative risk due to potential indoor air impact is greater than 10^{-5}.

Although multiple VOCs are present at a given location, a close examination of the risk drivers indicate that carbon tetrachloride and chloroform are consistently two primary risk drivers which contribute more than 90 percent of risks over the areas where cumulative risk level exceeding the 10^{-5} target risk level. Trichloroethene (TCE) is the third COPC that contributes more than 30 percent of risk at some locations. For all locations, not more than two of the above three COPCs are co-located so action levels based on an equal split of the 10^{-5} target cumulative risk among these three COPCs will provide a set of conservative action levels for the shallow soil vapor. Achieving these cleanup levels will incidentally cleanup other co-located COPCs as well. Alternatively, higher action levels can be used at locations where there is only one primary risk driver. Action levels corresponding to one and three risk drivers are listed in the Table 6.1 below.

Table 6.1 Shallow Soil Vapor Risk Drivers and Proposed Action Levels

COPC	Risk at the Unit Soil-Vapor Concentration (=1 ug/L) [1]	Proportional Contribution To The Target Risk Level (10^{-5})		Shallow Soil Vapor Action Levels (ug/L)	
		Three Risk Drivers	One Risk Driver	Three Risk Drivers (Lo)	One Risk Driver (Hi)
Carbon Tetrachloride	1.84E-07	1E-5 / 3	1E-5	18	54
Chloroform	2.98E-08	1E-5 / 3	1E-5	112	336
TCE	8.90E-09	1E-5 / 3	1E-5	374	1124

[1] From Appendix B, Table 11; this is the most-stringent value of all the exposure scenarios.

Action levels based on three risk drivers are more conservative and are therefore recommended to be considered the action levels for the shallow soil vapor plume where more than one risk drivers are present. Action level corresponding to one risk driver is applicable for locations where only one risk driver is present.

Soil Vapor Action Levels Protective of Groundwater

The fate and transport evaluation was also performed to derive a set of soil vapor action levels that are protective of groundwater. Because relatively lower soil vapor concentrations in the shallow soil which is more than 70 ft from groundwater table, potential impact of the shallow soil vapor to groundwater is less stringent than potential impact on indoor air. This is demonstrated from fate and transport analysis for the shallow soil. Consequently, fate and transport analysis is only conducted for the deep (>10 ft) soil vapor plume to derive the action levels for the deep soil vapor. The results indicate that the several deep soil vapor VOCs would impact groundwater above water quality goals (WQGs) (Table 6.2). Remedial actions are required to cleanup the deep vapor plume. Based on the fate and transport analysis, the deep soil vapor action levels that are protective of groundwater for a number of VOCs are summarized in Table 6.2 (below). As discussed previously for the shallow vapor plume, many of those VOCs are not co-located so the primary VOCs may be different from location to location. At the location where carbon tetrachloride is present, achieving action levels for carbon tetrachloride will most likely to meet the action levels for other co-located VOCs.

Table 6.2 Primary Soil Vapor COPCs and Proposed Deep Soil Vapor Action Levels

Chemicals Of Concern	Water Quality Goal (WQG) (ug/L)	WQG Source [1]	Average *Deep Soil Vapor* Action Level to Meet WQG (ug/L)
Carbon Tetrachloride	0.5	CA. Primary MCL	107
cis-1,2-Dichloroethene	6	CA. Primary MCL	3,705
Dichloro-difluoro-methane (CFC-12)	390	Tap water PRG	906,685
Chloroform	100	LARWQCB	2,512
Ethylbenzene	300	CA. Primary MCL	1,798,500
Trichloroethene (TCE)	5	CA. Primary MCL	8,281
Trichlorofluoromethane (CFC-11)	150	CA. Primary MCL	109,788
Xylenes (total)	1750	CA. Primary MCL	6,332,500

[1] USEPA Region 9, 2002; Title 22 California Code of Regulations §64444; LARWQCB, Interim Site Assessment and Cleanup Guidebook (A-8). May 1996.

Although actions levels are estimated for all 8 COPCs modeled, carbon tetrachloride and chloroform are the only two compounds for which the soil vapor action levels are lower than actual concentrations observed at the Site. So achieving action levels for carbon tetrachloride and chloroform for soil vapor in the deep vadose zone soil achieves the overall remedial action objectives for the deep soil vapor plume for the Site.

7 TECHNOLOGY SCREENING

This section of the RAP presents the results of screening and evaluation of remedial technologies and approaches that were considered to address impacted shallow soil and deep soil vapor at the Site.

7.1 SHALLOW SOILS

Shallow soils at the Site have been found to contain several different classes of contaminants, including; VOCs, SVOCs, pesticides/PCBs, TPH, and to a lesser extent, metals. Remedial options including excavation and off-site disposal, excavation and *ex situ* treatment, and a range of *in situ* treatment approaches were considered. Each of these alternatives is discussed below.

- *Excavation* – Excavation involves the use of heavy construction equipment to physically remove the impacted soils. Excavated material can then be treated on-site and returned to the excavation as clean fill or can be transported to a permitted landfill or other licensed facility for disposition. This approach is generally considered cost effective when the target area is small, shallow, well characterized and does not require extensive engineering measures such as shoring, building relocation, utility relocation, or dewatering to safely implement. The fate of the excavated soil must also be considered in selection of this approach. On site treatment can be costly if multiple technologies are needed to separate the contaminants from the excavated material and capture or destroy them. Off site disposition of the excavated material is costly, but generally feasible in most applications.
- *In Situ Treatment* – *In situ* treatment involves removal, stabilization and/or destruction of the contaminants without removal of the soil matrix. Many conventional and innovative approaches for *in situ* treatment have been developed and used for this application. They include physical removal (such as SVE for volatile constituents), chemical treatment (such as chemical oxidation and solidification/stabilization), and biological treatment (the use of native or non-native bacteria to transform the contaminants to harmless by-products). Some constituents, including PCBs, have been shown to be particularly recalcitrant to these *in situ* remedial measures. Further, as with *ex situ* treatment alternatives, multiple technologies may need to be applied to address different classes of constituents, if present in the target area.

Excavation and off-site disposal has been selected to address the shallow soils at the Site for the following reasons:

- The target soils are shallow, well characterized and located in accessible areas;
- Multiple classes of constituents are present, which would require several *in situ* and/or *ex situ* treatment technologies to address; and
- An extended *in situ* treatment program would adversely impact the overall project schedule.

7.2 SOIL VAPOR PLUME

The soil vapor plume consists of VOCs within the vadose zone between ground surface and groundwater table, located 80 to 130 feet bgs. Excavation and *in situ* treatment approaches were considered to address these soils and the associated soil vapor plume. *In situ* treatment of these soils was selected for the following reasons:

- Excavation of these soils would be impractical and costly due to their depth;
- The deeper soils contain VOCs, which are readily addressed by several, well-established *in situ* remediation techniques; and
- *In situ* remediation using SVE has been demonstrated at the Site to be successful in addressing these constituents through the pilot-scale system previously discussed.

The *in situ* remedial approach selected for the deep soils and associated soil vapor plume is SVE. SVE is an *in situ* technology that induces airflow within the unsaturated zone by withdrawing air from the subsurface through wells or trenches. The airflow effectively removes the volatile compounds within the soil vapor and enhances the evaporation of nonaqueous phase liquids (NAPL), the volatilization of VOCs dissolved in pore water, and the desorption of VOCs from soil particle surfaces (USACE, 1995). SVE is most effective at sites such as this, with relatively permeable contaminated soil that has saturated hydraulic conductivities greater than 1×10^{-5} centimeter per second (cm/s) (USEPA, 1997).

The successful demonstration of SVE at this site confirms the applicability and efficacy of this technology for removing VOC soil vapors from the vadose zone. The SVE system has operated since 2000 as part of an IRM for the Refrigerant Plan source area. The pilot SVE system was installed in accordance with the LARWQCB approved *Interim Corrective Action Plan* (Brown & Caldwell, Parsons, 1999). In a little more than three years, the pilot SVE system removed an estimated 110,000 pounds of VOCs. Vapor concentrations in vapor monitoring wells within the treatment zone decreased by at least one order of magnitude (Soil RI Report, Parsons 2004d). The decreased soil vapor concentrations are direct evidence that the majority of the VOC mass in vadose zone soil beneath the Refrigerant Plant source zone has been successfully removed. The proposed Site-wide soil vapor remedial action would consist of the installation of additional vapor extraction wells to cover the three areas where the vapor plume exceeds action levels. Detailed design (based on individual well pilot studies) for the expanded SVE system will be presented in an SVE System Start-Up Work Plan. Operating procedures for the system will be subject to ongoing testing and optimization. Details on off-gas treatment are discussed in Section 9.

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8 REMEDIAL ACTION PLAN FOR IMPACTED SHALLOW SOIL

Based on overriding considerations of efficiency, effectiveness, and potential to achieve the RAOs set forth in Section 6, the remedial action selected for shallow impacted soil, less than 10 feet below the ground surface, is excavation and off-site disposal. The effectiveness of the lateral and vertical extent of the excavation will be determined through confirmation sampling and the evaluation of COPC concentrations using a risk-based process. Demolition of site facilities is complete and remediation of shallow soil is in progress following the approach developed in the *Revised IRM WP* (Parsons, 2004b).

Deeper soils in select areas of the Site are impacted with VOCs, with the exception of one area which has TPH above the RI SSL but which poses no significant risk. The remedial action plan for the impacted shallow soils (soil matrix) at the Phase I and Phase II Redevelopment parcels is discussed in Sections 8.1 and 8.2, respectively. The remedial action plan to address the deeper soils and the associated soil vapor plume on a Site-wide basis is presented in Section 9.

8.1 PHASE I PARCELS (REFRIGERANT PLANT AND SW CORNER LOT)

8.1.1 Interim Remedial Measure (IRM) for Shallow Soil

Stepwise RI soil screening to identify potential hot spots was conducted by applying the most conservative screening standards among USEPA direct contact PRGs, soil vapor ESLs, and TRPH goals of the LARWQCB. Recently some additional sites were identified and/or existing hot spots further delineated as a result of the Step 5 data gap RI and post-demolition soil sampling. A summary of RI data and the potential hot spots that were identified in this process is presented in Section 2 (Table 2.1.3 and Figure 2.2.1).

All potential hot spots that emerged from the RI screening process were subjected to detailed human health risk assessment (HHRA) for the suite of COPCs present at each hot spot, and for various exposure scenarios including the contribution of soil vapor. Location-specific RBCGs were then developed based on the process set forth in the RBCG Report (Parsons, 2004c). The logic of the IRM process, from RI screening through risk-based remediation to determination of no further action (NFA), is presented on the IRM Soil Removal Decision Tree (Figure 8.1).

Tables 5.2A and 5.2B present cumulative risk assessment summaries for the hot spot areas that failed RI SSL screening. Table 5.2A presents the risks for hot spots identified during the Steps 1-4 RIs, which were also covered in the *Revised IRM WP*. Table 5.2B presents the same information for additional hot spots identified based on the Step 5 RI results and post-demolition soil sampling. Tables 8.1A and 8.1B identify the specific COPC risk drivers and indicate whether remediation is warranted based on the cumulative risk and cumulative hazard calculations. Details for hot spots in Table 8.1A are summarized in the *Revised IRM WP* but detailed RI findings for hot spots in Table 8.1B are included in the Step 5 RI Report (Parsons, 2004f). Detailed risk assessment results to estimate action levels for remedial action are provided in Appendix B and summarized in Section 5. The location and extent of the soil hot spots selected for soil remediation are presented on Figure 8.2.

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The IRM hot spot soil removal action consists of hot spot soil removal driven by site-specific risk-based cleanup levels. For the Refrigerant Plant and SW Corner Lot parcels, screening and confirmation sampling of soil exposed by demolition have been completed in accordance with the *Revised IRM WP*. Final steps for completion of the remedial action for each hot spot include confirmation soil sampling, additional excavation as needed, collection of additional confirmation samples, and comparison to the RAOs presented in Section 6. When concentrations of COPCs are either non-detectable or below the RBCGs for that hot-spot, closure is achieved.

8.1.2 Confirmation Sampling

Post-excavation confirmation samples are being collected in accordance with methods and standards described the *Revised IRM WP* (Parsons, 2004b). All confirmation soil samples will be analyzed for the hot spot-specific risk driver COPCs. The confirmation analyses are performed using the same analytical methods and detection limits used during the step-wise remedial investigations. To minimize costly delays in field decision-making, samples are typically analyzed on an expedited basis and the analytical results are evaluated in the field during excavation activities. The analytical results are compared to the hot-spot-specific RBCGs to determine if further excavation and/or confirmation sampling are necessary.

8.1.3 Final Risk Assessment

As discussed in Section 5, the final risk assessment conducted using all soil matrix data has shown that completion of the ongoing soil removal action in accordance with the approach presented in the *Revised IRM WP* will effectively remediate all impacted soils that pose unacceptable risks. Cumulative risks greater than 10^{-5} and/or HI greater than 1 are considered unacceptable risks. With the exception of the soil vapor plume remediation which is discussed separately in Section 9, the ongoing soil IRM is the final remedial action for the Site soil (soil matrix) and completion of soil IRM will complete the soil remedial action for the soils for all Phase I parcels (Refrigerant Plant and Southwest Corner Lot).

8.1.4 IRM Completion Report

Due to the complexity of the Site and interim remedial actions proposed, multiple reports will be prepared for IRM completion and closure. Hot spot removal is currently underway. On-site activities for Site investigations and demolition have been completed. Once the shallow soil excavation work is complete and the necessary confirmation sampling results have been reviewed and validated, a closure report will be prepared that documents the remedial excavation field work. The report will include analytical results from all confirmation samples; supplemental risk assessment to derive the hot-spot-specific RBCGs for the new hot spots identified in RI Step 5 and recent demolition activities; detailed maps of the location and extent of the remedial excavations; a full accounting of the fate of soil excavated and removed from the Phase I parcels; documentation of volume of soil removed; dust, VOC, and other environmental monitoring data; copies of all necessary permits; and annotated photo documentation of the remediation field work. Once compiled, this information will be assembled as a bound report and submitted to the LARWQCB.

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8.1.5 Closure of Shallow Soil

The objective of soil remedial action is to achieve shallow soil closure so the proposed development can proceed. Ultimately, Honeywell will seek NFA approval from the LARWQCB for the shallow soil for each Site parcel with the condition that remediation of soil vapor plume will be implemented.

8.1.6 Implementation Schedule

Implementation of the IRM for individual shallow soil hot spots is currently underway. Excavation of contaminated soil and confirmation sampling has been completed for several hot spots and excavation is continuing at other hot spots. The IRM Completion Report will be submitted within 30 days of completing IRM field work.

8.2 PHASE II REDEVELOPMENT PARCEL (UND-4 AND -5)

The Phase II Redevelopment involves the UND-4 and -5 parcels. The Risk-Based Cleanup Goals Report (Parsons 2004c), the *Revised IRM WP* (Parsons, 2004b), and this RAP provide the framework and methods by which the UND-4 and -5 parcels will be evaluated as well as any other potential shallow soil hot spots identified during ongoing Site activities. A detailed remedial action plan taking into consideration the unique characteristics of the UND-4 and -5 parcels will be presented under separate cover.

9 REMEDIAL ACTION PLAN FOR VOC VAPOR PLUME

As discussed in Section 2, two distinct VOC vapor plumes have been identified. The first is a plume of chloroform, carbon tetrachloride, and CFCs originating from the general Refrigerant Plant area. The second is the TCE and cis-1,2-DCE plume associated with the SW Corner Lot parcel. While remedial action for soil is only necessary to cleanup the Refrigerant Plant area vapor plume per the RAOs established in Section 6, SVE systems will be installed within both plumes. This section describes elements of the RAP for each VOC vapor plume at a conceptual design level. Precise well locations, screened intervals and operational parameters are subject to revision during the detailed design. Additional pilot tests may be conducted for individual wells to support the detailed design. Final design and the as-built drawings for the expanded SVE system will be presented in an SVE system start-up and initial performance assessment report. Operating procedures for the system will be subject to ongoing testing and optimization.

9.1 SOIL VAPOR EXTRACTION – REFRIGERANT PLANT PLUME

9.1.1 Existing Pilot SVE System

As discussed in Section 7, a pilot-scale SVE system has been successfully operated within the Refrigerant Plant plume. The pilot test phase began in October 2000 with extraction of soil vapor from vapor extraction well VEW-2. Twelve additional extraction wells were installed and connected since that time (VEW-1 through VEW-4 and VEW-8 through VEW-15). Operation of these wells was cycled to optimize extraction between September 2002 through March 2004, when demolition activities precluded further system operation (RETEC, 2004).

9.1.2 Conceptual Full-scale SVE System Layout

In spite of significant decreases in COPC concentrations in soil vapor beneath the Refrigerant Plant from the pilot system, concentrations remain above action levels beneath and surrounding the Refrigerant Plant (Sections 2 and 6). Expansion of the SVE system is proposed to reduce the COPC concentrations to acceptable levels. The conceptual design of the expanded, full-scale SVE system is described in the remainder of this section.

The full-scale SVE system will include the installation and operation of up to 30 new vapor extraction wells (VEWs). The preliminary location of these VEWs is illustrated on Figure 9.1.1. The location and spacing of the VEWs is based on a zone of influence of 130 feet that was measured and demonstrated to be effective during the operation of the pilot-scale SVE system. Construction details of the proposed additional VEWs are illustrated in Figure 9.1.2. VEWs will be screened across depth intervals with soil vapor concentrations above cleanup goals. Nested riser pipes with screened intervals at alternate depths will be placed where the vertical extent exceeds 30 feet.

The well-heads of the new VEWs will be connected to an extraction blower using underground piping. Based on the proposed land use, SVE piping and piping manifolds pipes will be buried up to 36 inches bgs. Piping and piping manifolds will generally consist of Schedule 80 PVC. Piping may be installed in phases as other site construction progresses. Piping from the VEW well heads will be 2-inch diameter, while manifold piping that connects multiple well-heads together will be 3-inch, 4-inch, or 6-inch diameter, depending

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on the number of wells connected. The manifolds will connect to the vacuum blower housed in a central treatment equipment enclosure.

9.1.3 Offgas Treatment System

9.1.3.1 Previous Refrigerant Plant Offgas Treatment System

A cryogenic system was recommended in the *Interim Corrective Action Plan* as the selected SVE off-gas treatment technology after careful evaluation of innovative treatment technologies and weighing community concerns (Brown & Caldwell, Parsons, 1999). The RWQCB approved this technology in June 2000. The cryogenic treatment system was capable of treating the high concentrations of VOCs encountered during the pilot testing (over 24,000 ppmv), while meeting South Coast Air Quality Management District (SCAQMD) effluent limits.

The cryogenic treatment system is an innovative, condensation-based treatment process selected to separate the VOCs from the influent vapor. Figure 9.1.3 presents a block process flow diagram for the vapor extraction and cryogenic condensation treatment process. Prior to entering each compressor assembly, the extracted influent vapor is routed through a water knockout drum where entrained water is captured. The condensation process uses a dual, skid-mounted compressor assembly to extract and compress the soil vapor to approximately 150 pounds per square inch (psi). The compressed vapors are stored in a receiver vessel and cooled to near ambient temperatures with an after-cooler. The compressed vapor is then routed from the after-cooler through a series of air-to-air heat exchangers and refrigerated heat exchangers that sequentially chill the vapor to a temperature of approximately -45°F. After the refrigeration stage of the treatment process, the condensed VOCs are separated, recovered and containerized for disposal. The vapor stream containing residual, non-condensable gases is routed through two proprietary regenerative adsorber trains, operated in series, followed by carbon polishing prior to discharging to the atmosphere.

9.1.3.2 Proposed Refrigerant Plant Offgas Treatment Approach for the Full-scale SVE

Other innovative technologies were investigated to identify technologies that could allow an increased flow rate without creating potential air pollutants. However, the only other treatment technology with the ability to treat high concentrations of VOCs with significant proportion of light CFCs at a high flowrate was flameless thermal oxidation (FTO). However, the local community group, "Committee to Bridge the Gap", opposes any thermal technology because of potential generation of dioxin and furans. Hence, cryogenic treatment of SVE offgas remains the only viable alternative for the Site. This technology was successfully demonstrated at the Site during pilot testing. The key disadvantage to cryogenic technology is the limited flowrate, generally around 160 cubic feet per minute (cfm).

In the future, as the influent concentrations of CFCs decrease, an off-gas concentrator could be added in front of the cryogenic system. An added concentrator would increase the influent flow capacity by an order of magnitude. Potential concentrator technologies include zeolites and membrane technologies, which are both currently limited in their ability to adsorb CFCs. However, decreasing CFC concentrations will allow one of these concentrator technologies to be used effectively in conjunction with carbon polishing and the cryogenic system, allowing an acceleration of site cleanup while meeting regulatory ozone depletion discharge standards.

9.1.4 Permits

9.1.4.1 Construction Permits

Installation of the cryogenic system will require obtaining an electrical permit from the City of El Segundo. In addition, a plan check of the piping system may be required.

9.1.4.2 Air Permit

A South Coast Air Quality Management District (SCAQMD) "permit-to-operate" was obtained for the cryogenic system in 2002. Hence, cryogenic system operation may continue under the existing permit. If an added concentrator module is to be installed at a future date once CFC concentrations decrease, then the permit will need to be modified. The modified system must be in compliance with SCAQMD Rule 1415, which stipulates CFC emission limits.

9.1.5 System Design, Construction and Startup

Detailed design documentation will be prepared prior to construction of the full-scale SVE system. The detailed design will include a well location diagram, piping and instrumentation diagrams and other documentation to facilitate permitting, procurement, and construction of the system components. The system design will also take into consideration the Site development plan. A carefully designed monitoring program will also be developed to allow for timely performance assessment to ensure efficient system operation and optimization.

The SVE system will be constructed in accordance with the design and applicable permits. A comprehensive quality assurance and quality control program will be implemented to ensure the construction will conform to the design specifications. An updated health and safety plan will also be developed to ensure safe implementation.

At the completion of construction, a troubleshooting/modification/optimization process will be followed to ensure efficient system operation in accordance with the design and applicable permits. A startup report will be submitted to the LARWQCB within 90 days of system startup. The startup report will provide as-built drawings and initial performance data.

9.1.6 System Operation and Maintenance

The cryogenic system generally must be checked every 2 or 3 days. System pressures, temperatures, and flow rates will be monitored. Condensate and product recovery drums will be checked and switched out as needed. System influent, carbon influent, and effluent samples will be collected and analyzed by a field gas chromatograph (GC), as approved previously by the SCAQMD, to meet the requirements of the treatment system air permit.

Recovered solvent will be transported by a certified waste transporter and either recycled or incinerated off-site. Condensate water also will be transported by a certified waste transporter and treated off-site. Spent vapor-phase carbon used for polishing treatment will be regenerated off-site.

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9.1.7 Performance Monitoring, Evaluation and Optimization

A number of vapor monitoring wells already exist in the vicinity of the Refrigerant Plant plume and, depending on their condition after site demolition activities, may be deemed adequate for monitoring the full-scale system. These wells include VMP-1, VMP-2, 1D, 9D, 20D, 23D - 35D, and 37D. The condition of these vapor monitoring wells will be verified, and if their integrity is deemed in good condition then they will be used to periodically monitor the zone of influence and progress toward remedial action goals. Vapor samples will be collected in Tedlar bags and analyzed using a field PID, a field GC, a mobile laboratory, or a fixed laboratory.

Individual monitoring and extraction wells will be monitored at least quarterly during the first year to evaluate changing concentrations. A performance report will also be submitted to the LARWQCB on a quarterly basis for the first year. Monitoring frequency and reporting may be adjusted for subsequent years based on LARWQCB approval. Vapor samples will be collected in Tedlar bags and analyzed using a field PID, a field GC, a mobile laboratory, or a fixed laboratory. Wells will be opened or closed to maximize mass removal from the subsurface and to reach remedial action goals.

CFC concentrations in the extracted vapor are expected to decrease more rapidly than the other VOC constituents. Once the CFC concentrations have decreased to a point that they can be treated with an alternative technology while meeting applicable SCAQMD discharge regulations for CFCs, then addition of a concentrator will likely become economical. The concentrator will allow more extraction wells to be operated simultaneously, increasing the overall flowrate by an order of magnitude. The concentrated vapor stream will continue to feed to the cryogenic system, while the dilute air stream will be polished using carbon or biofiltration to levels the meet applicable discharge regulations for CFCs.

9.1.8 Re-bounding Test/ Confirmation Sampling

Selected extraction wells will be periodically turned off for several weeks or months to evaluate rebound. Rebound is the percent that soil vapor concentrations increase after extraction has been terminated. Wells in which the concentration does not rebound above 20% of initial concentrations will be viewed as stable.,

Soil confirmation sampling may be performed in selected areas after soil vapor cleanup goals have been met.

9.1.9 Termination

Individual wells will be turned off once cleanup goals have been met. Once rebound testing indicates that action levels have been met within the Refrigerant Plant plume, a request for the system termination will be prepared.

Typically at contaminated sites, not all residual contamination can be recovered even using proven technologies such as an SVE system, particularly when the contaminant mass is bound up within low-permeable soils or the capillary fringe. Asymptotic extraction concentrations are often an indicator of such a situation. If this appears to be the case, which indicates technical impracticality to achieve these RAOs, then a request will be made to terminate operation of the SVE system.

9.1.10 Implementation Schedule

Following approval of this RAP and in coordination with the site construction schedule, the cryogenic system will be remobilized to the Site, temporary piping installed, and extraction will resume from existing VEWs. Concurrently, design and installation of additional VEWs will proceed. Permanent piping will then be trenched and installed to connect the new and existing VEWs to the cryogenic treatment unit.

9.2 SOIL VAPOR EXTRACTION – OLD SOLVENT WAREHOUSE PLUME

As discussed in Section 6, VOC concentrations in soil vapor beneath the Old Solvent Warehouse area are already below action levels. However, elevated concentrations of VOCs have been detected near the surface of the water table zone and may be associated with groundwater off-gassing. A pilot test is being considered to evaluate the effectiveness of collecting these vapors. The SVE system considered in this section will reduce the residual soil vapor plume in the vadose zone and supplement or become part of the groundwater source treatment system proposed in the pending *Conceptual Groundwater Remedial Action Plan and Data Gap Remedial Investigation Work Plan* (Conceptual Groundwater RAP; Parsons, 2004f).

9.2.1 Conceptual SVE System Layout

The conceptual SVE system for the Old Solvent Warehouse area includes one extraction well to be installed to collect vapors that may be produced by the pilot-scale air sparging system. Based on the Refrigerant Plant pilot SVE system, the radius of influence for SVE wells are on the order of 130 feet and hence one VEW is adequate to recover any sparged vapors that may emerge into the vadose zone from the pilot air sparing system. Figure 9.2.1 illustrates the location of the proposed VEW in the Old Solvent Warehouse area.

The VEW screen interval will be positioned just above the groundwater table in the area of highest soil vapor concentrations. This also will be the optimal depth to recover vapors from the air sparging pilot system. Based on the proposed land use, SVE header pipes may need to be buried 18 to 36 inches bgs but specific details will be worked out in close coordination with the redevelopment plan to ensure conformance. Piping will generally consist of PVC Schedule 80 to provide added protection during site construction activities. Individual lines will be 2-inch diameter, and manifold pipes will be 2-inch or 4-inch diameter, depending on the number of wells that will potentially be connected.

9.2.2 Offgas Treatment System

A separate treatment system will be provided for the Old Solvent Warehouse plume in conjunction with the proposed air sparging system for the groundwater pilot treatment system described in the Conceptual Groundwater RAP (Parsons, 2004f).

Various off-gas treatment technologies were evaluated for this separate SVE system. Extracted vapor concentrations during air sparging could exceed 1,000 µg/L initially, but will likely drop below 1,000 ug/L after several months of operation. Based on this assumption and the identified COPCs (primarily TCE and cis-1,2-DCE), treatment with activated carbon will be the most cost-effective treatment technology. Based on vendor isotherm results and assuming influent concentrations of TCE at 200 µg/L and cis-1,2-DCE at 800 µg/L, and a

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flow rate of 200 cfm, the carbon usage rate would be approximately 140 pounds per day, requiring changeout of a 2,000 lb vessel approximately every two weeks. This is a cost-effective range for SVE operation. Figure 9.2.2 presents a block process flow diagram for the SVE and carbon treatment process.

9.2.3 Permit

9.2.3.1 Construction Permits

Installation of the SVE system will require obtaining an electrical permit from the City of El Segundo. In addition, a plan check of the piping system may be required.

9.2.3.2 Air Permit

Pre-permitted SVE units with carbon treatment are available for rent. Such a pre-permitted system could be operated during the first year while a site-specific SCAQMD permit application is underway. Based on concentration trends observed during the first six months, it may be decided that procuring a long-term treatment system will not be necessary for the Old Solvent Warehouse area (i.e., if the majority of mass is removed through the pilot system). More details are provided in Conceptual Groundwater RAP (Parsons 2004?).

9.2.4 System Design, Construction and Startup

Detailed design will be performed to ensure optimum placement of wells, piping and treatment systems and to ensure that the remedial system will be in conformity with the proposed redevelopment.

The SVE system will be constructed in accordance with the design and applicable permits. A comprehensive quality assurance and quality control program will be implemented to ensure the construction will conform to the design specifications. An updated health and safety plan will also be developed to ensure safe implementation.

At the completion of construction, a troubleshooting/modification/optimization process will be followed to ensure efficient system operation in accordance with the design and applicable permits. A startup report will be submitted to the LARWQCB within 90 days of system startup. The startup report will provide as-built drawings and initial performance data.

9.2.5 System Operation and Maintenance

An SVE treatment system with carbon is simple to operate and maintain. Typically, a monthly maintenance routine is adequate to maintain the units in good working order. During these monthly visits, filters and oil are checked and changed as needed. More frequent visits may be needed to monitor for carbon breakthrough and to assist with carbon changeouts.

9.2.6 Performance Monitoring, Evaluation and Optimization

MW-17, located within the core of the TCE and cis-1,2-DCE Old Solvent Warehouse plume, already has four nested monitoring points. These will be monitored periodically to evaluate concentration trends. Vapor samples will be collected in Tedlar bags and analyzed either using a field PID or by a certified laboratory. Individual extraction wells also will be monitored at least quarterly to evaluate changing concentrations and the impact of the air sparging.

Compliance effluent samples from the SVE system will be collected in Tedlar bags and analyzed by a certified laboratory monthly. The influent vapor concentration to the SVE treatment system also will be monitored at this time.

9.2.7 Re-bounding Test/ Confirmation Sampling

Rebound testing and soil confirmation sampling will not be required in the Old Solvent Warehouse area because RAOs for the vapor plume have already been met.

9.2.8 Termination

SVE operation will be terminated once the air sparging groundwater treatment is complete.

9.2.9 Implementation Schedule

After approval of this RAP and the Conceptual Groundwater RAP, procurement and installation of the VEWs and SVE piping network will proceed. A pre-permitted SVE treatment system will be mobilized to the Site and SVE will commence contingent on the site redevelopment schedule.

9.3 CONTINGENCY PLAN

9.3.1 Vapor Barrier for Select Buildings

The proposed installation of the SVE system discussed above will be implemented prior to or concurrent with site development. Operation of the SVE system will focus initially in the proposed building areas and will likely allow attainment for site RAOs regarding vapor intrusion concerns. However, as a contingency, vapor barriers may be installed during the construction of site buildings in the areas with potential vapor intrusion concerns to ensure human health risks are below those identified in Section 6.

Areas where risk-based RAOs due to the indoor air pathway, the most stringent pathway, may be exceeded are identified on Figure 9.3.1. The figure also shows proposed building footprints and proposed shallow soil vapor monitoring wells. If SVE fails to satisfactorily reduce vapor concentrations below the Site action levels for indoor air protection prior to the building construction, then vapor barriers will be installed to ensure protection of human health.

9.3.2 Air Quality Monitoring

A routine soil vapor monitoring program will be implemented to achieve the following objectives:

- Monitor the soil vapor concentration changes in shallow soils (<10 ft bgs) around building footprints to ensure protection by monitoring the soil vapor concentration trends in areas outside the SVE treatment zone and where vapor barriers are not installed.
- Monitor soil vapor concentration changes in the SVE treatment areas to assess the effectiveness of the SVE remedial system and facilitate optimization/modifications to improve effectiveness/efficiency.

Figure 9.3.1 shows the location of the proposed soil vapor monitoring well network. Most of the multi-depth vapor monitoring wells already exist (installed as part of the SVE pilot

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system and recent site investigation). Additional monitoring wells will also be installed. Monitoring may also be conducted from conduits, horizontal trenches, or the gravel base installed beneath buildings.

When observed increases in soil vapor concentrations in any shallow soil vapor monitoring wells indicate potential indoor air concerns, direct indoor air monitoring will be conducted to ensure protection.

Soil vapor monitoring will be conducted on a quarterly basis for the first year and adjusted to semiannual or annual monitoring later based on the available data at that time. Analytical parameters will include the Site VOCs.

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